CHAPTER 5.4

Management of the Cassava Mosaic Disease Pandemic in East Africa

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Introduction

During the 1990s, a pandemic of an unusually severe form of cassava mosaic disease (CMD) expanded to cover a large part of East Africa, including virtually the whole of Uganda and parts of western Kenya, southern Sudan, north-western Tanzania and eastern Democratic Republic of Congo (DRC) (Otim-Nape et al., 1997; ASARECA, 1998; Legg et al., 1999b). This has been associated with the occurrence of a novel and highly virulent cassava mosaic begomovirus (Deng et al., 1997; Harrison et al., 1997; Zhou et al., 1997). Surveys to assess the prevalence and severity of CMD were conducted in Uganda, Kenya and Tanzania as part of the diagnostic phase of the Tropical Whitefly Integrated Pest Management (TWF-IPM) Project (Chapters 1.6, 1.7 and 1.8, this volume). A principal outcome of these surveys was the identification of regions that were either currently affected or threatened by pandemic expansion, based on epidemiological data (Legg et al., 1999b).

In view of the acute effects of the severe CMD associated with the pandemic, the co-ordination team of the TWF-IPM Project considered that there was an immediate need to identify sources of funding to support CMD control activities in recently affected/threatened areas. Dialogue was initiated with staff of the United States Agency for International Development (USAID) by the Project Co-ordinator and subsequently followed up in Uganda by the co-ordinator of the Africa-based Sub-Project 4. A concept note was submitted to the Office for Foreign Disaster Assistance (OFDA) of USAID in April 1998 and funding for a 1-year project was approved the following month. The project, entitled "Emergency programme to combat the cassava mosaic disease pandemic in East Africa" began in October 1998 and this first phase was completed in September 1999.

Background to Control of the CMD Pandemic

After a decade of major losses to cassava production in Uganda due to the CMD pandemic (Otim-Nape et al., 1997), substantial experience has been gained on control strategies. CMD-

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resistant cassava germplasm introduced from the International Institute of Tropical Agriculture (IITA) in the early 1980s was evaluated in multi-locational and on-farm trials during the early 1990s and, in 1993, three cultivars (TMS 60142, TMS 30337 and TMS 30572) were officially released under the names Nase 1, Nase 2 and Nase 3 (or Migyera). In addition to being resistant to infection, they were tolerant also of the effects of cassava mosaic begomoviruses (CMBs) once infected (Thresh et al., 1994). Multiplication efforts were initiated during the mid-1990s (Otim-Nape et al., 1994; GCF, 1997) and areas initially targeted included some of the first areas to be affected by the pandemic in northern and eastern Uganda (Otim-Nape et al., 1994).

In more recent years, as the pandemic has expanded southwards, the emphasis of control efforts has shifted to central and southern districts. At the end of 1997, a major project funded by the PL 480 programme of USAID and entitled "Dissemination and utilization of mosaic resistant cassava in Uganda" was initiated in the central-southern target districts of Masindi, Luwero, Mukono, Kamuli and Iganga. Principal CMD management themes within this programme were monitoring and diagnostics, plant health management within the multiplication scheme and participatory evaluation of new CMD-resistant germplasm. The project targeted districts that had been affected by the CMD pandemic for more than 1 year and therefore already were experiencing significant shortages of planting material. This project did not address districts affected more recently, in 1996 and 1997, as identified by the TWF-IPM Project diagnostic surveys.

Pandemic control in western Kenya and open quarantine

The expansion of the pandemic into western Kenya was first noted in 1995 (Gibson, 1996; Legg et al., 1999b) although it was not until 2 years later as the increasing seriousness of the problem was recognized that initiatives began to control it. The key constraint to CMD management in western Kenya was the virtual absence of any CMD resistant germplasm in the country. In order to address this problem, scientists of the East African Root Crops Research Network (EARRNET) worked with plant quarantine officials of both Uganda and Kenya to develop guidelines for the establishment of an "open quarantine" facility. This was sited at Busia, on the Kenyan side of the Kenya/Uganda border, and allowed the introduction of stem cuttings of two CMD resistant cultivars, SS4 and TMS 30572 (Nase 3), in addition to a wide range of selected clones from the EARRNET germplasm development programme, based at Serere, Uganda. It was also at this time that the pandemic control programme in western Kenya received its first major offer of financial support, from the Gatsby Charitable Foundation (GCF) in the UK. EARRNET co-ordinated the development of a project, funded by GCF, which provided for the introduction, evaluation and multiplication of CMD-resistant cultivars in western Kenya and was initially targeted to run for 3 years.

Regional pandemic control and the OFDA CMD Project

Whilst USAID and Gatsby-funded initiatives were providing substantial support for the multiplication and dissemination of CMD resistant cultivars in Uganda and Kenya, it was clear that the increasing regionalization of the CMD pandemic needed to be addressed by taking a more pro-active

and co-ordinated approach. It was envisaged that such an approach would involve establishing links between control efforts in each of the East African countries affected or about to be affected by the pandemic, and targeting monitoring and control initiatives towards "threatened" zones in addition to areas already affected. This was the rationale behind the development of the OFDA-funded project, which began in October 1998.

The purpose of the OFDA CMD Project was to "boost production of cassava in Uganda, Kenya and Tanzania and enhance both short and longer term food security, through the implementation of an emergency programme to multiply and disseminate mosaic resistant cassava". Principal partners included IITA-Eastern and Southern Africa Regional Center (ESARC), the two regional root crops networks of EARRNET and the Southern African Root Crops Research Network (SARRNET) and national root crops programmes in Kenya, Tanzania and Uganda. Principal project activities were organized under five themes:

(1) Monitoring and diagnostics: conduct focused surveys in south-western Uganda, western Kenya and north-western Tanzania to provide detailed distribution maps of CMGs in the project target areas and baseline data for subsequent impact analysis.
(2) Multiplication: multiply and distribute in collaboration with project partners, elite CMD-resistant materials.
(3) Germplasm diversification: increase the range of cassava materials available to farmers in areas targeted by the project, thereby reducing future risk of production collapse.
(4) Stakeholder linkages: identify and strengthen links between key stakeholders with roles in enhancing cassava production in target areas.
(5) Farmer training: develop producer skills in identification and management of cassava pests and diseases with special focus on CMD, in addition to basic production and multiplication skills.

Implementation Highlights—The OFDA CMD Project

Significant progress was made in the attainment of project targets in each of the main themes and the project has been successful in fostering a more comprehensive regional approach to tackling the CMD problem.

Monitoring and diagnostics

An important feature of the project has been the use of regular monitoring and diagnostic surveys to assess the status of CMD in threatened zones and develop forecasts for the likely pattern of development of the pandemic. Surveys focused on the Kagera region in north-west Tanzania and Western and Nyanza Provinces in western Kenya. During the first quarter of the project, the first report was made of severe CMD in Kagera and subsequent virus diagnoses using specific polymerase chain reaction (PCR) primers confirmed the association of severe CMD in this region with the presence in diseased plants of mixed infections of *African cassava mosaic virus* (ACMV) and the Uganda variant of *East African cassava mosaic virus* (EACMV-Ug) (Legg and Okao-Okuja, 1999). The occurrence of mixed ACMV/EACMV-Ug infections is characteristic of the "front" of the CMD pandemic (Harrison et al., 1997) and the associated severe symptoms are the main reason for its acute impact on cassava cultivation in affected areas.

In western Kenya, the distribution of CMGs appears to be complex and ACMV, EACMV and EACMV-Ug have been reported (Ogbe et al., 1996; Legg and Okao-Okuja, 1999). Monitoring surveys in late 1998 demonstrated the apparent slowing of the spread of the pandemic. This was possibly as a result of the presence of major natural barriers between north and south Nyanza Province (Kisumu area), which include the Winam Gulf of Lake Victoria and the Kano Plains, an expanse of flood plain in which cassava cultivation is virtually absent (Legg et al., 1999a). Although high incidences of severe CMD have yet to be reported from south Nyanza, the pandemic-associated EACMV-Ug has been detected from Migori, near the Tanzania border.

Data obtained from monitoring and diagnostic surveys have been used to develop regional CMD maps and their presentation has been an important tool in raising awareness amongst agricultural workers based in threatened zones. It is considered also that presentation of these graphics has been a key component in persuading both national agricultural institutions and donor agencies to take seriously the threat posed by the pandemic to regional cassava production and, with it, food security.

Multiplication

The multiplication and dissemination of CMD-resistant cultivars has been the main control technique used in tackling the CMD pandemic in Uganda and it has fulfilled the same role in the OFDA CMD Project in the wider region. Approaches to multiplication differed in each of the three participating countries, however, since the availability of planting material differed substantially in each. In Uganda, stems of cultivar SS4 were obtained from the USAID-funded PL 480 Project and used to plant 15 ha in each of Rakai and Masaka Districts.

In western Kenya, by contrast, less than 4 ha of CMD-resistant cultivars were present at the outset of the project, at the open quarantine site. The OFDA CMD Project joined GCF and the Rockefeller Foundation in supporting the multiplication of this material and by June 1999 the area of CMD-resistant material had increased to more than 35 ha.

In north-western Tanzania, the last of the three countries to be affected by the pandemic, only a small number of plants of CMD-resistant varieties were present by the end of 1998 and therefore more vigorous action had to be taken to obtain resistant material. As a consequence, whilst lobbying the Tanzania Ministry of Agriculture and Co-operatives for permission to establish open quarantine in Kagera, tissue culture plantlets were requested from IITA, Ibadan, Nigeria, and an intensive programme of true irrigated rapid multiplication (IITA, 1998) of available CMD-resistant cultivars was expanded at Ukiriguru Agricultural Research Institute (ARI), Mwanza. By June 1999, cassava planting material equivalent to almost half a million cuttings had been multiplied, more than 10,000 tissue culture plantlets of CMD-resistant cultivars had been imported from IITA, Nigeria and proposals for the establishment of open quarantine had been approved.

Germplasm diversification

Broadening the genetic base of cassava is seen as a key aspect of a balanced approach to the management of cassava pests and diseases. This is particularly important with respect to the CMD pandemic, since a heavy emphasis on the development of germplasm with high levels of resistance to CMD has resulted in less

attention being given to other important pest and disease constraints. A practical result of this is that the two varieties most widely multiplied for CMD control in East Africa, SS4 and TMS 30572, are relatively susceptible to cassava green mite damage. In more recent germplasm development work, greater emphasis has been placed on multiple pest and disease resistance and germplasm with these characteristics is now becoming available both through national breeding programmes and through the EARRNET regional germplasm development programme.

In Uganda, two demonstration sites have been established in Rakai and Masaka and include nine cultivars that are currently being evaluated in national on-farm trials. In Kenya, more than 500 clones were introduced to the open quarantine site from the EARRNET programme based at Serere and the best 15 of these were multiplied for "fast-track" multi-locational testing in 2000. In Tanzania, more than 20 elite cultivars from the multiplication programme are under evaluation in areas of the Kagera region most severely affected by the pandemic, and new cultivars with novel West African landrace-derived sources of CMD resistance formed part of the recently imported tissue culture consignment from IITA, Nigeria. Each of these initiatives should help ensure that a diversity of cultivars is ultimately made available to farmers that should minimize losses likely to result from future pest or disease outbreaks.

Training

Changes resulting from the CMD pandemic are dramatic, and experience obtained from Uganda shows that farmers are typically unaware of the likely impact at the outset and frequently continue with cassava cultivation for a number of years, suffering substantial yield losses, before finally abandoning the crop. Raising awareness and the provision of training in CMD management are key requirements if this type of scenario is to be avoided. Training for both extension workers and farmers therefore has been an important part of the OFDA CMD Project. Various fora have been used for training exercises including:

(1) Stakeholder workshops: held at the outset of the project in each of the three countries. Information provided on the cause, spread, impact and strategy for the management of the CMD pandemic.
(2) *In-situ* training: farmers and extension workers have been trained in cassava pest management and multiplication techniques at multiplication sites.
(3) Individual training: researchers from participating countries have been trained in virus diagnostic techniques and have been sponsored to participate in regional CMD scientific meetings.
(4) Community training: village leaders have been trained in north-western Tanzania to facilitate the transfer of information down to grassroots level.
(5) Formal course training: the project has helped sponsor courses on seed multiplication in Tanzania and on cassava production, protection and utilization in Kenya, principally targeted at local agricultural workers.

In addition to the provision of training through courses or demonstration, use has been made of the media, particularly in Tanzania, where local radio communications have provided information on the CMD pandemic to a much greater number of households than could have been achieved using other methods.

Stakeholder linkages

The key to the success the project has achieved to date is largely attributable to the active participation of many cassava stakeholders in target areas. These include non-governmental organizations, government district agriculture offices, farmer training centres and projects funded by multi-lateral donors. The inclusion of a broad range of partners has the twin advantages of fostering ownership of the project at local level and enhancing local co-ordination. The development of a local steering committee for western Kenya, which was charged with the responsibility for co-ordinating cassava development and multiplication activities in that region, was an important development in which the OFDA Project participated (ASARECA, 1999).

Conclusions

In a relatively short period of time the OFDA CMD Project, affiliated to the TWF-IPM Project, has made significant achievements in both establishing a regional collaborative mechanism for the monitoring and management of the CMD pandemic and actually implementing control measures. A key advantage of the pro-active approach the project is taking, with its emphasis on targeting threatened zones, is that lead times for the implementation of control measures may be significantly reduced compared with previous experience in Uganda. Given the magnitude of losses associated with the CMD pandemic (Legg et al., 1999b; Otim-Nape et al., 1997; Thresh et al., 1997), this is an important development. The multi-faceted approach being pursued by the Tanzania Root and Tuber Crops Programme with its partners, and supported by the Project, also is considered to be a useful model for other countries threatened by the pandemic in the near future. Given the likely continued expansion of the pandemic into other neighbouring countries, similar such vigorous responses will be essential if major losses are not to continue across the cassava-producing areas of East and Central Africa.

Acknowledgements

The OFDA CMD Project was funded through a grant from the Office for Foreign Disaster Assistance of the United States Agency for International Development.

References

ASARECA (Association for the Strengthening of Agricultural Research in Eastern and Central Africa). 1998. Cassava mosaic pandemic threatens food security. AgriForum 3:1 and 8.

ASARECA (Association for the Strengthening of Agricultural Research in Eastern and Central Africa). 1999. Fighting cassava mosaic pandemic: Networking critical. AgriForum 7:1 and 12.

Deng, D.; Otim-Nape, G. W.; Sangare, A.; Ogwal, S.; Beachy, R. N.; Fauquet, C. M. 1997. Presence of a new virus closely associated with cassava mosaic outbreak in Uganda. Afr. J. Root Tuber Crops 2:23-28.

GCF (Gatsby Charitable Foundation). 1997. Mastering mosaic: The fight for cassava production in Uganda. Gatsby Occasional Paper, London, GB. 24 p.

Gibson, R. W. 1996. The report of a survey monitoring the spread of the epidemic of *African cassava mosaic virus* from Uganda into western Kenya. Internal report, Natural Resources Institute (NRI), Chatham, GB. 17 p.

Harrison, B. D; Zhou, X.; Otim-Nape, G. W.; Liu, Y.; Robinson, D. J. 1997. Role of a novel type of double infection in the geminivirus-induced epidemic of severe cassava mosaic in Uganda. Ann. Appl. Biol 131: 437-448.

IITA (International Institute of Tropical Agriculture). 1998. Rapid multiplication of cassava. A colour pocketbook. Training and Extension publ. no. 122, Ibadan, NG. 61 p.

Legg, J. P.; Okao-Okuja, G. 1999. Progress in the diagnosis and epidemiological characterisation of cassava mosaic geminiviruses in East Africa. Procs. VIIth International Plant Virus Epidemiology Symposium, 11-16 April 1999. Aguadulce (Almeria), ES. Abstract: 74-75.

Legg, J. P.; Kapinga, R.; Teri, J.; Whyte, J. B. A. 1999a. The pandemic of cassava mosaic virus disease in East Africa: Control strategies and regional partnerships. Roots 6(1):10-19.

Legg, J. P.; Sseruwagi, P.; Kamau, J.; Ajanga, S.; Jeremiah, S. C.; Aritua, V.; Otim-Nape, G. W.; Muimba-Kankolongo, A.; Gibson, R. W.; Thresh, J. M. 1999b. The pandemic of severe cassava mosaic disease in East Africa: Current status and future threats. Akoroda, M. O.; Teri, J. M. (eds.). Procs. Scientific Workshop of the Southern African Root Crops Research Network (SARRNET), 17-19 August 1998, Lusaka, ZM. p. 236-251.

Ogbe, F. O.; Songa, W.; Kamau, J. W. 1996. Survey of the incidence of *African cassava mosaic* and *East African cassava mosaic viruses* in Kenya and Uganda using a monoclonal antibody based diagnostic test. Roots 3(1):10-13.

Otim-Nape, G. W.; Bua, A.; Baguma, Y. 1994. Accelerating the transfer of improved production technologies: Controlling African cassava mosaic virus disease epidemics in Uganda. Afr. Crop Sci. J. 2:479-495.

Otim-Nape, G. W.; Bua, A.; Thresh, J. M.; Baguma, Y.; Ogwal, S.; Semakula, G. N.; Acola, G.; Byabakama, B.; Martin, A. 1997. Cassava mosaic virus disease in Uganda: The current pandemic and approaches to control. Natural Resources Institute (NRI), Chatham, GB. 65 p.

Thresh, J. M.; Otim-Nape, G. W.; Jennings, D. L. 1994. Exploiting resistance to *African cassava mosaic virus*. Asp. Appl. Biol. 39:51-60.

Thresh, J. M.; Otim-Nape, G. W.; Legg, J. P.; Fargette, D. 1997. African cassava mosaic disease: The magnitude of the problem? Afr. J. Root Tuber Crops. 2:13-19.

Zhou, X.; Liu, Y.; Calvert, L.; Muñoz, C.; Otim-Nape, G. W.; Robinson, D. J.; Harrison, B. D. 1997. Evidence that DNA-A of a geminivirus associated with severe cassava mosaic disease in Uganda has arisen by interspecific recombination. J. Gen. Virol. 78:2101-2111.