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Research on African Cassava Mosaic Virus: the need for international collaboration

J.M. Thresh, D. Fargette and J. Mukiibi
Natural Resources Institute, Central Avenue, Chatham Maritime, Chatham, Kent ME4 4TB, UK, LPRC/CIRAD 34032 Montpellier Cedex 1 France, and Ministry of Agriculture, P O Box 2, Entebbe, Uganda.

There are so few virologists and vector entomologists in Sub-Saharan Africa that National Programmes can seldom mount major research projects on African cassava mosaic gemini virus (ACMV) and its whitefly vector *Bemisia tabaci*. The lack of information on control strategies is one of the reasons why the virus is so prevalent and causes such serious losses. An international collaborative approach, as mounted against the cassava mealybug, *(Phenacoccus manihoti)* would have obvious advantages in making the most effective use of the facilities and expertise available. Such approach is long overdue and some of the main issues to be addressed are: the importance of ACMV in different agro-ecological zones; -the existence of biotypes of *B. tabaci* that are restricted to cassava; rates of virus spread by whitefly vectors; the availability of ACMV-resistant and ACMV-free planting material; socio-economic studies of the attitude of farmers to such planting materials and to rogueing; and modelling vector populations, virus spread and the impact of control measures. The information on these topics now being obtained in Uganda and the methods being developed will be widely applicable elsewhere.

Introduction

African cassava mosaic gemini virus (ACMV) is prevalent in all the cassava growing areas of Africa and causes very serious losses. These losses could be decreased by the application of existing information on control by sanitation and/or virus resistant varieties. However, the available information is inadequate in relation to the magnitude of the problem and there is a need for additional research. This will be difficult to achieve due to the lack of the necessary facilities and expertise in many of the worst affected countries. There are obvious advantages in a coordinated collaborative approach to make the best possible use of the work being done by national and international programmes, with support from donors and other outside agencies. This paper emphasizes the need for further studies on epidemiology, vector ecology, modelling and socio-economics to develop and deploy effective control measures.

Research issues to be addressed

The incidence and severity of ACMV. The importance of ACMV tends to be underestimated and one reason for this is that there is little quantitative information on the incidence and severity of infection in the many African countries where cassava is grown. Recent experience in Uganda indicates that such information can be acquired quickly and inexpensively in routine surveys of representative plantings. These underestimate the incidence of infection because symptoms can be masked or overlooked and some plants are infected latently. Nevertheless, the Ugandan results show marked differences between districts in the overall incidence of infection, which ranges from 94% in the northern district of Kitgum, to only 28% in Jinja District near Lake Victoria. The information obtained has been used to distinguish high, intermediate and low risk areas and to develop appropriate control strategies for each.

Similar surveys are needed elsewhere and it is essential to distinguish clearly between 'disease incidence' (the proportion of plants infected) and 'disease severity' (the type and extent of symptoms). The widely used ACMV scoring systems of 0-4 or 1-5 do not do this and provide only general impressions of symptom expression. This is misleading because scores of 2 or 3 could indicate that all plants are infected and show symptoms of intermediate severity or that half the plants are uninfected and the others very severely affected.

Effects of ACMV on growth and yield. Work in East, West and Central Africa has shown the deleterious effects of ACMV on the yield of cassava. Losses of up to 95% have been reported in plants infected as cuttings. Plants infected at a later stage by the whitefly vector *Bemisia tabaci Gennadius* are less severely affected and there is a positive relationship between symptom severity and crop loss. A serious limitation of the available information is that few trials have been done with the improved ACMV-resistant varieties now being promoted in many countries. Another difficulty is that little account has been taken of interactions within plant populations and of the possibility that uninfected plants compensate for the impaired growth of infected neighbours. If this occurs, there is likely to be a critical incidence of infection within stands below which overall yields are unaffected. This could be an important varietal feature that determines whether sanitation or other control measures are necessary if suitably resistant varieties are used. There is, therefore, a need for definitive experiments with infected and uninfected plants of a range of resistant and partially resistant varieties in various proportions and in conditions of high and low infection pressure.

Rates of spread of ACMV. The spread of ACMV into and within cassava plantings has been assessed in several countries and very different results have been obtained. Little spread occurred at several sites, including those in coastal and western Kenya and in the inland Savannah zone of Côte d'Ivoire. By contrast, spread was rapid at lowland sites in Tanzania and in the coastal forest zone of Côte d'Ivoire. Such results are important in indicating the prospects for control by sanitation and the need for ACMV-resistant varieties. However, it is difficult to compare the published data because they were obtained at different times using different varieties and their relative susceptibility to infection is not known. An even greater difficulty is that information is completely lacking from vast tracts of Africa either because trials have not been done, or in some instances because ACMV-free planting material is not available for experiments. There is an obvious need for more additional information and for developing uniform experimental designs and recording procedures, using a range of varieties. These should include suitable standard varieties that are planted in all trials to facilitate comparisons between countries. It will then be possible to relate spread to vector populations and to assess the relative importance of rainfall, temperature, cropping intensity and other factors that influence vector populations and rates of virus spread.

Whitefly biology. ACMV is widely disseminated in cuttings but the only known means of spread between plants is by *B. tabaci*. The biology of this species on cassava has been studied at IITA, Ibadan and in coastal districts of Kenya and Côte d'Ivoire, but there is a need for additional information from these areas. Moreover, they represent only some of the many agro-ecological zones in which cassava is grown. There is obvious scope for international collaboration in developing standard whitefly sampling and recording procedures so that vector populations in different countries can be related to climatic data and to rates of virus spread in the epidemiological trials being assessed. Additional topics for study include the possible role of *B. afer* Priesner & Hosny as a vector of ACMV and variation within and between populations of *B. tabaci* in host range and in their effectiveness as virus vectors. It is particularly important to determine whether the populations of *B. tabaci* that occur on cassava and transmit ACMV have a restricted host range and differ from those on other hosts as suggested by studies in Côte d'Ivoire.

Modelling studies. Experience with several plant virus diseases has shown the value of mathematical modelling techniques in understanding the dynamics of disease progress, vector populations and the impact of environmental factors, rogueing and other possible control measures. Initial studies (D. Fargette, unpublished) based on experience in Côte d'Ivoire have shown the great potential for adopting this approach to ACMD and *B. tabaci*. Accurate simulations of vector populations and virus spread have been made based on temperature conditions or solar radiation, whereas rainfall appeared to be relatively unimportant as a determinant of spread. Moreover, the model has been linked to crop loss data to predict effects on yield. It also takes account of differences in host resistance, vector populations, rogueing frequency/ intensity and in the proportion of plants that are infected as cuttings and that recover from infection. An important prediction from the model is that the incidence of infection does not necessarily increase in successive plantings of the same stock until virtually all plants are infected. Under certain conditions, dynamic equilibria are reached in which spread by whiteflies is counter-balanced by the effects of rogueing and/or recovery from infection.

It is important to assess the validity of the initial model under different agro-ecological conditions, including areas where rainfall and soil moisture are less favourable for cassava growth than in the humid lowland forest zone of Côte d'Ivoire. The model should also be tested using a range of varieties and rogueing strategies in conditions of different innoculum pressure.

Socio-economic studies. ACMV can be controlled through the use of ACMV-resistant varieties but an alternative or complementary approach is by sanitation. This involves the release of ACMV- free planting materials and rogueing. These approaches have been widely advocated and could bring great benefits. However, their adoption has been limited and is critically dependent on the performance of extension services and other agencies in providing advice and on the response of farmers. This emphasizes the need for socio-economic studies on attitudes to rogueing and to evaluate different methods of producing and distributing stocks of improved varieties and ACMV-free cuttings on the vast scale required. Experience with improved varieties in Cameroon and Nigeria and with ACMV-free stocks in Uganda is that very different approaches are possible involving Government or Non-Governmental organizations (NGOs) and it is important to evaluate the advantages and disadvantages of each method of production and distribution. Studies are also required on the response of farmers to new varieties and to determine whether they can be persuaded to select or purchase ACMV-free cuttings and to rogue. Such studies are now proceeding in Uganda and are linked with on-farm trials to determine the most appropriate rogueing procedures to adopt and the circumstances in which sanitation is likely to be most effective.

Discussion

The need for additional studies on the epidemiology and control of ACMV reflects the inadequate information that is available on these topics. There is currently only a limited amount of work in progress, especially when considered in relation to the great importance of cassava in Africa and to the magnitude of the problem posed by ACMV. There is obvious scope for new initiatives and for a major international effort comparable to that mounted in the 1980s to combat the new threats posed by the introduction of the cassava mealybug *phenacoccus manihoti* (Mat.-Ferr.) and green mites *Mononychellus* spp. to Africa. Such a project on ACMV will not be easy to arrange and would require substantial commitments from donors. Meanwhile, much could be achieved by closer collaboration between existing research groups than has been achieved in the past, to make more effective use of the scarce facilities and expertise available. This is the approach being adopted in Uganda where a comprehensive programme on the epidemiology and control of ACMV has been mounted by the national Root Crops Programme in collaboration with various Non-NGOs including the World Bank, FAO, Oxfam and the Gatsby Charitable Foundation and with support from IITA, IDRC, USAID, ORSTOM, EEC and NRI. Much new information is being obtained and many of the procedures and research findings will be applicable elsewhere. They will be made available through existing organizations such as the Eastern and Southern Africa Root Crops Research Network and the International Society for Tropical Root Crops, but other possibilities should be explored.

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