AFRICAN CASSAVA MOSAIC

INTRODUCTION

African cassava mosaic virus (ACMV) has caused immense damage leading to severe food shortages in the African region (sub- Saharan Africa), Angola, Kenya, Uganda, Nigeria and the Seychelles. Cassava (*Manihot esculenta* L. Crantz) is a food staple in most African countries.
This disease has not yet been reported in the Caribbean or in the Latin American region.
The African cassava mosaic virus (ACMV) belongs to the group of unique viruses – Gemini virus, which is transmitted by the whitefly *Bemisia tabaci* Genn. This disease in Africa originally referred to as cassava mosaic (CMD) or more recently as African cassava mosaic disease (ACMD) was reported in 1894, in what is now Tanzania (Thresh et al.1998c). Early studies in several of the then colonial territories showed that CMD was transmissible by grafts and by the adult whitefly, *B. tabaci*. In 1975, sap inoculations from diseased cassava to healthy cassava and to the herbaceous host, *Nicotiana clevelandii* Gray, were successful (Bock, 1975).

Identity

Classification

Genome	: (+) ssDNA
Family	: Geminiviridae
Genus	: *Begomovirus*
Species	: *African cassava mosaic virus*
Synonyms	: Cassava latent virus, Cassava mosaic virus, Cassava African mosaic virus
Role	: Pest

There are three confirmed strains: type strain isolate 844 (Bock et al.1978); Kenya coast (C) strain (Bock et al.1981), and Angola defective isolates (Sequeira and Harrison, 1982).

Signs & Symptoms

Symptoms on the main host, Manihot esculenta, are severe mosaic and leaf distortion, leading to defoliation and severe stunting (**Fig. 1**).
The UgV strain which has caused a severe destructive CMD epidemic in Uganda in 1988 (Harrison et al. 1997a, 1997b) causes severe symptoms especially when it super-infects plants already infected with ACMV (Legg et al. 2001) **(Fig. 2).**

Morphology

Particle (virion) morphology is geminate and characteristically twinned particle morphology, and bipartite and not enveloped; 20nm in diameter; the dimer is 30nm in length; slightly angular in profile, without a conspicuous capsomere arrangement. Two sedimenting components in purified preparations; sedimentation coefficient of the fastest (main) component 76 S; of the other (s) 50S. Virions (virus particles) contain 22% nucleic acid;78% protein. The genome consists of DNA, single stranded (ssDNA) and circular.

Biology & Epidemiology

African cassava mosaic virus is the only geminivirus reported from cassava in Africa. However, in South America, similar symptoms are caused by Cassava common mosaic, a potexvirus, which also causes local lesions in *Chenopodium amaranticolor* and *Gomphrena globosa* and is not transmitted by *Bemisia tabaci* (Costa and Kitajima, 1972). Viruses associated with two other mosaic diseases of cassava in Colombia are not sap transmissible to *Nicotiana benthamiana*. Preliminary research showed that all isolates from CMD⁻ affected cassava in different parts of Africa and also from India were all different strains of African cassava mosaic geminivirus. However, serological testing and nucleotide sequencing later distinguished three groups of isolates as separate viruses and referred to as African cassava mosaic virus (ACMV), East African cassava mosaic virus (EACMV) and Indian cassava mosaic virus (ICMV), respectively (Swanson and Harrison, 1994). All three viruses are members of the recognized family: Geminiviridae: Sub-Family III: Begomovirus (Thresh et al., 1998).

It is also not surprising that findings have suggested that the distributions of ACMV and EACMV are not as distinct as originally thought. The continuing research in the late 1990s advanced knowledge on the ACMV. Ogbe et al. (1996, 1997) detected EACMV in some samples from western districts of Kenya and Tanzania where previously only ACMV has been reported. Further, EACMV was detected together with ACMV in a severely diseased plant in Western Tanzania on the island of Ukerewe in the South of Lake Victoria (Harrison et al.1997b). There was also a finding that a novel geminivirus variant designated UgV has been isolated and found to be associated with the very severe CMD pandemic which affected areas of Uganda and parts of western Kenya (Harrison et al. 1997a,1997b; Zhou et al.1997). The variant had been detected in southern Sudan and more recently in Rawanda, (Legg et al. 2001). UgV has the serological properties of ACMV but from nucleotide sequencing data it also has features of the EACMV genome. Consequently, UgV is considered to be a recombinant between EACMV and ACMV, although its exact status and origin are uncertain.

Dispersal / vectors

The viruses causing mosaic diseases of cassava are disseminated in the stem cuttings used routinely for propagation and they are also transmitted between plants by the whitefly vector (*Bemisia tabaci)*. This implies that it is very important that the epidemiology is understood with respect to means of transmission, which in turn would impact the management strategies. This understanding would also determine what emphases should be laid in phytosanitation including use of virus-free cuttings and the removal (roguing) of any diseased plants that can occur.

High rainfall more than 1200mm favours more spread than in locations that are drier and having a shorter growing season and where less cassava is grown (Bock, 1983).

Hotter and more humid the region the more virulent is the disease. Virulence in the sense of incidence of infection diminishes with increased altitude, so that at altitudes of over 1300m it was possible to grow varieties that had been abandoned on the coast because of their vulnerability to infection (Cours-Darne, 1968). Storey (1936) had earlier noted that the spread of CMD was less in Upland areas of Tanzania (> 1000m a.s.l.) than at lower altitudes.

Very rapid spread occurred in plantings of susceptible varieties. This rapid spread was at first associated with the dry savannah conditions where whitefly population densities and

temperatures were higher in the dry season are longer and more intense than in the more humid forest areas to the south (Otin-Nape et al.1997b).
High whitefly vector populations are known in high temperatures and rainfall to 'drive' the epidemic.
However, research done in Uganda provided conflicting information. This epidemic was associated with UgV strain which caused severe symptoms especially in plants that also contained ACMV (Harrison et al., 1997a, 1997b; Zhou et al.,1997). The incidence was lowest in southern districts bordering Lake Victoria and highest in the drier grassland savannah areas of central and northern Uganda where serious epidemics of CMD have caused severe food shortages and hardship in recent years (Otini-Nape, 1993; Thresh et al. 1994b; Otini-Nape et al.1997b).

Management

Main emphasis has been on the use of resistant varieties and phyto-sanitation, which involves the adoption of CMD-free planting material and the removal (roguing) of any diseased plants that occur later (Thresh et al.1998a). Virus-free cassava planting material can be produced by heat treatment and meristem-tip culture (Bock, 1983). However, the most effective means of deploying resistant varieties and of practising phytosanitation have not been determined and there is a need to develop simple but durable and effective measures that farmers are prepared to accept and adopt on a sufficiently large scale. Moreover, farmers and consumers are understandly reluctant to accept virus resistant or otherwise improved varieties unless they also meet their existing criteria. These include the taste and palability of the tuberous roots, growth habit and overall suitability for use in the cropping system.
CMD resistant varieties have several important features (Fargette et al.1996; Thresh et al. 1994b, 1998a, 1998b).
1) Resistant varieties are much less readily infectible than susceptible varieties. The CMD resistant varieties develop inconspicuous symptoms, especially at the later stages of crop growth and may even become symptomless.
Consequently, they grow and yield satisfactorily even if infected at or at an early stage;
2) Localized distribution of virus and the overall concentration tends to be low. This suggests that resistant plants are a poor source of inoculum from which spread can occur, but evidence for this has not been sought;
3) Uninfected cuttings can be obtained from infected plants because of the localized distribution of virus. This is the 'reversion' phenomenon that has important epidemiological consequences in restricting the deterioration in health status that would otherwise occur during successive cycles of propagation. In summary, farmer participatory approach in the adoption process of managing Cassava mosaic disease can be essential for sustainability. Selection of resistant/tolerant varieties to the African cassava mosaic virus and its pattern of a cropping system balanced to enhance production are integral of the farmers' participatory approach. Selection of virus-free planting material of cultivars with moderate resistance is important, since the disease can be transmitted by stem cuttings. Culling of fields of plants showing CMD infection is also an important means to reduce infection in the fields.

Pest Significance

Since African cassava mosaic disease (ACMV) has not yet been found in the Caribbean and Latin American countries, it goes without emphasizing that all diligence and importance must be attached to all quarantine measures to prevent and/or delay the spread of this most destructive disease to the region.

Host Notes	Warburg (1894)

Manihot esculenta, Nicotiana glutinosa– severe mosaic and leaf distortion leading to loss of leaves and severe stunting of plants **(Figure 1).**
Hewittia sublobata –mosaic (probably the natural host of the Kenya coast strain (Bock et al.1981)*Laportea (=Fluerya aestuans*-bright chlorosis (possibly the natural host in Nigeria (Anon. 1979)*Manihot glaziovii* - mosaic

Distribution

ACMV is found in Africa, India, Madagascar, Mauritius, Seychelles, Bioko, Cape Verde Islands, (Thresh et al 1998).

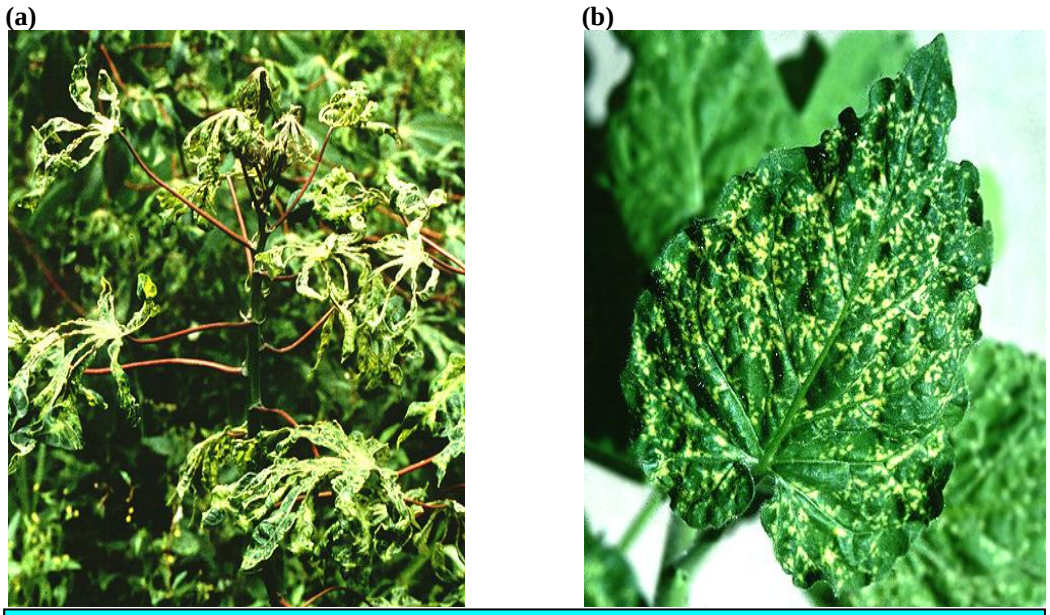

Figure 1: Severe mosaic and leaf distortion on (a) cassava and (b) tobacco plants
(Courtesy P Mc Grath)

(a) (b)

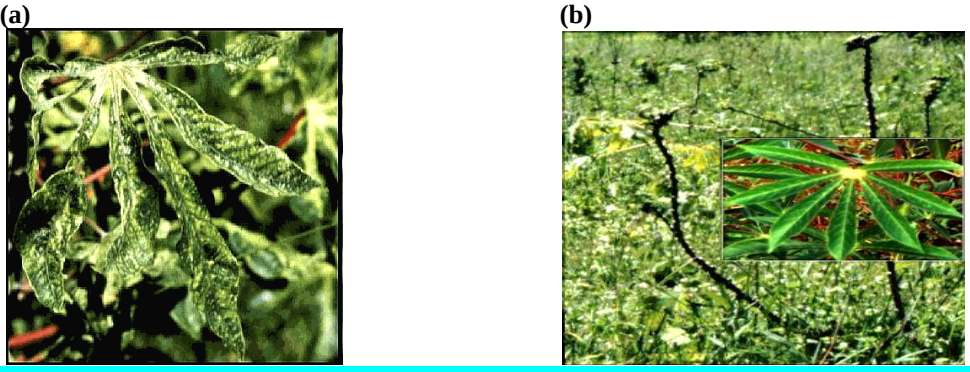

Figure 2: Severe leaf distortion and leaf loss caused by ACMV/EACMV recombinant
(Photos by E.P Rybicki, 1997)

Bibliography

Adejare, G.O., and Coutts, R.H.A. (1982). The isolation and characterisation of a virus from Nigerian cassava plants affected by the cassava mosaic disease, and attempted transmission of the disease. Phytopathologische Zeitschrift 103:198-210

Anon, (1979). Report, International Institute of Tropical Agriculture, 1978::p 107.

Bock, K.R. (1975). Maize streak, cassava latent and other similar viruses In: Abstracts of the Third Congress of Virology, Madrid, Spain, p.93

Bock, K.R. (1983). Epidemiology of cassava mosaic disease in Kenya. In: Plant Virus Epidemiology (Ed.by Plumb.R T Thresh,J M.) pp.337-347.Blackwell Scientific Publications, Oxford ,UK.

Bock, K.R., and Guthrie, E.J. (1982). Control of Mosaic disease in Kenya. Tropical Pest Management 28:219

Bock, K.R., and Woods, R.D. (1983). Etiology of African cassava mosaic disease. Plant Disease 67: 994-995

Bock, K.R,. and Harrison, B.D. (1985). African cassava mosaic virus.ABB Descriptions of Plant Viruses.No.297. 6pp

Bock, K.R., Guthrie, E.J., Meredith, G., and Barker, H. (1977). RNA and protein components of maize streak and cassava latent viruses. Annals of Applied Biology 85:305-308

Bock, K.R., Guthrie, E.J., and Meredith, G. (1978). Ann. Appl. Biol.90:361

Bock, K.R., Guthrie, E.J., and Figueiredo, G. (1981). Ann. Appl. Biol.99: 151

Brunt, A.A., Crabtree, K., Dallivitz, M.J., Gibbs, A.J., Watson, L., and Zurcher, E.J. (eds). 1996. Plant Viruses online; Descriptions and Lists from the VIDE Database Version; 20th August, 1996. URL

Costa, A.S., and Kitajima, E.W. (1972). Cassava common mosaic virus. CMI/AAB Descriptions of Plant Viruses: No 90.4 pp.

Cours-Darne, G. (1968). Improving cassava in Africa. The Abidjan Conference.

Agricultural Research for Economic Development in Africa 2:330-339
Fargette, D., Fauquet, C., and Thouvenel, J.C. (1985). Field studies in the spread of African Cassava Mosaic. Annals of Applied Biology. 106: 285-294
Fargette, D., Colon, L.T., Bouveau, R., and Fauquet, C. (1996). Components of resistance of cassava to African cassava mosaic virus. European Journal of Plant Pathology 102: 645-654
Hamilton, W.W.O., Stein, V.E.,Coutts, R.H.A., and Buck, K.W. (1984). EMBO J 3:2197
Harrison, B.D. (1985). Ann. Rev. Phytopath. 23:55
Harrison, B.D., Liu, Y.L., Zhou, X., Robinson, D.J., Calvert, L., and Otim-Nape, G.W. (1997a) Properties, differentiation and geographical distribution of geminiviruses that cause cassava mosaic. African Journal of Root and Tuber Crops 2:19-22
Harrison, B.D., Zhou, X., Otim-Nape Liu, Y., and Robinson, D.J. (1997b). Role of a novel type of double infection in the geminivirus-induced epidemic of severe cassava mosaic I Uganda. Annals of Applied Biology 131: 437-448
Legg, J.P., Okao-Okuja, G., Mayala, R., and Muhinyuza (2001). Spread into Rwanda of the severe cassava mosaic virus disease pandemic and associated Uganda variant of East African cassava mosaic virus (EACMV-Ug). New Disease Reports – Spread into Rawanda of the severe cassava mosaic virus disease
Ogbe, F.O., Songa, W., and Kamau, J.W. (1996). Survey of the incidence of African cassava mosaic and East African mosaic viruses in Kenya and Uganda using a monoclonal antibody based diagnostic test. Roots 3 : 10-13
Ogbe, F.O., Legg, J., Raya, M.D., Miumba-Kankalongo, A., Theu, M.P., Kaitisha, G., Phiri, N.A., and Chalwe, (1997). Diagnostic survey of cassava mosaic viruses in Tanzania, Malawi and Zambia. Roots 4: 12-15
Otim-Nape, G.W. (1993). The epidemiology of the African cassava mosaic geminivirus disease in Uganda. PhD Thesis University of Redding 252 pp
Otim-Nape, G.W., Bua Aand Thresh, J.M.(1997). Eds. Progress in cassava technology transfer in Uganda NARO/Gatsby/NRI Publication,Chatham Maritime, U K,39 pp
Roberts, I.M., Robinson, D.J., and Harrison, B.D. (1989). J. gen. Virology 65:1723
Robinson, D.J., Harrison, B.D., Sequeira, J.C., and Duncan, G.H. (1984). Detection of strains of African cassava mosaic virus nucleic acid hybridization and some effects of temperature on their multiplication. Annals of Applied Biology 105: 483-493
Sequeira, J.C., and Harrison, B.D. (1982). Serological studies on cassava latent virus. Annals of Applied Biology 101: 33-42
Storey, H.H.(1936).Virus diseases of East African Plants VI. A progress report on studies of the disease of cassava. East African Agricultural Journal 2: 34-39
Swanson, M.M,, and Harrison, B.D.(1994). Properties, relationships and distribution of cassava mosaic geminiviruses. Tropical Science 34: 15-25
Thresh, J.M., Fargette, D., and Otim-Nape, G.W. (1994a). Effects of African cassava mosaic geminivirus on the yield of cassava. Tropical Science 34: 26-42
Thresh, J.M., Fargette, D., and Mukiibi, J. (1994b). Research on African cassava mosaic virus: the need for international collaboration. In: Root Crops for Food Security in Africa. Proceedings 5th Triennial Symposion of the International Society for Tropical Root Crops – Africa Branch.(Ed.by Akoroda, M.O.),pp 271-274.IITA, Ibadan, Nigeria
Thresh, J.M., Otim-Nape, G.W., Legg, J.P., and Fargette, D. (1997). African cassava mosaic virus disease: the magnitude of the problem. African Journal of Root and Tuber Crops 2: 13-17
Thresh, J.M., Otim-Nape, G.W., Fargette, D. (1998a). The control of African cassava

mosaic virus disease: Phytosanitstion and/or resistance. In: Plant Virus Disease Control. (Ed. by Hadidi , A., Ketarpal, R.K., Koganezawa, H.), APS Press, St Paul Minnesota. Pp 670-677

Thresh, J.M., Otim-Nape, G.W., and Fargette, D. (1998b).The components and deployment of resistance to cassava mosaic disease. Integrated Pest Management Reviews

Thresh, J.M., Otini-Nape, G., Thankppan, M., and Munigappa, V. (1998c).The mosaic diseases of cassava in Africa and India caused by white-fly-borne geminiviruses. Review of Plant Pathology 77:936-945

Townsend, R., Watts, J., and Stanley, J. (1986). Synthesis of viral DNA forms in Nicotiana plumbaginifolia protoplasts inoculated with cassava latent virus (CLV); evidence for the independent replication of one component of the CLV genome. Nucleic Acids Research 14: 1253-1265

Walker, P.T., Heydon, D.L., and Guthrie, E.J. (1985). Report of a survey of cassava yield losses in Ghana. Tropical Development Research Institute Report CO/479,9 pp

Warburg, O. (1894). Mitt. Deutch. Schutzgeb.7: 131

Wydra, K., and Maikita, W. (1998). An overview of the present situation of cassava diseases in West Africa. Proceedings:Sixth Triennial Symposium of the International Society for Tropical Root Crops:-Africa Branch (Ed. By Akoroda M O;Ekanayake I)

Zhou, Z., Liu, Y., Calvert, L., Munoz, D., Otim-Nape, G.W., Robinson, D.J., and Harrison, B.D.(1997). Evidence that DNA-A of a geminivirus associated with severe cassava mosaic disease in Uganda has arisen by interspecific recombination. Journal of General Virology 78: 2101-2111

Web Resources: -

http:/ / biologyanu.edu.au/Groups/MES/vide.
http://www.bspp.org.uk/ndrjul2001/2002-htm