

Plant Virus and Viroid Diseases in the Tropics

K. Subramanya Sastry · Thomas A. Zitter

Plant Virus and Viroid Diseases in the Tropics

Volume 2: Epidemiology and Management

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Foreword



This textbook entitled “Plant Virus and Viroid Diseases in the Tropics-Volume 2: Epidemiology and Management” is an ideal introduction to the subject written for students, practitioners and researchers by Drs. K. Subramanya Sastry and T. A. Zitter. The authors focused on physical and biological factors that favor epiphytotics, including weeds that can constitute virus reservoirs as well as breeding foci for vectors. Virus properties, survival and spread by invertebrate vectors, nematodes and fungi, are followed by the description of spatial dynamics, disease gradients, forecasting,

and mathematical modeling techniques. Seven important tropical diseases their ecology and epidemiological aspects are described in detail.

In the [Chap. 1](#), the well organized overview of virus survival and spread, disease forecasting, disease gradients and progress curves, systems analysis and simulation models are covered.

The [Chap. 2](#), the authors have presented the outlines of the management of tropical plant virus and viroid diseases, the selection of virus-free seed and propagules, techniques of production of virus-free plant materials by biotechnological strategies, barrier cropping, time of planting, eliminating of weeds, use of insecticides and use of transgenic plants-the most effective control measure.

The important role of plant quarantine is stressed. Certification schemes for seed-borne viruses in lettuce, barley, pea, beans, soybean, cowpea and peanuts, as well as production of virus-free plants and certification schemes through tissue culture techniques are discussed for cassava, citrus, potato, sugarcane and other plants. Cultural practices and phytosanitation in virus and viroid diseases, as well as cross-protection in fourteen virus diseases are described in detail.

Control of vectors by oil and insecticides are discussed in great detail, as is also the use of aluminum mulches for vector control. Sources of resistance and transgenic approaches to viral and viroid diseases, benefits and risks, are

enumerated. Technical guidelines for exchange of germplasm and breeding lines, with detailed descriptions of methods of plant importation are described.

This authoritative review will provide a unique education platform to the readers, so that they can keep in touch with the latest developments in the field of tropical plant virus diseases. Drs. K. Subramanya Sastry and T. A. Zitter have substantial practice in tropical plant viruses and this invaluable book is meticulously researched. It will appeal to all those with an interest in tropical plant virus diseases and their control.

New Brunswick, USA

Karl Maramorosch

Preface

Many of the world's most important food crops are grown in the tropics and major crops like rice, maize, wheat, sorghum, barley, tomato, chillies, okra, peas, peanut, sunflower, cucurbits, pigeonpea, etc., are raised through true seed, whereas cassava, potato, sweet potato, sugarcane, cocoa, avocado, apples, banana, and other fruit crops are grown through vegetative propagated materials like tubers, sets, rhizomes, cuttings, budwood, etc. Almost all these crops are affected by important virus and viroid diseases besides fungal and bacterial diseases. However, emergence of new viruses and virus strains of existing viruses, along with changing contexts due to agricultural intensification and climate change have been creating new challenges and demanding an even greater effort to overcome hurdles to increase agricultural productivity, food availability, and economic development. These diseases are responsible for heavy yield losses. We have definite chemical measures against fungal and bacterial diseases, whereas until now no promising viricides have been developed to control virus spread.

Disease-free crops and plants are of great economic and social importance in feeding the world population. The thrust of the book Volume-2 is on virus and viroid disease in the tropics in order to provide the latest information on ecology, epidemiology, and management of virus and viroid diseases in southeastern Asian countries, the African, and South American continents, which fall within the tropical zone. Plant viruses are a matter of great concern globally, but effective management measures against plant viruses requires a clear understanding of their ecology and epidemiology.

Environmental factors like rainfall, wind velocity, soil conditions, temperature, and moisture play a major role in crop production. Among the major virus diseases that are encountered in tropical zones are tungro, yellow mottle and hoja blanca in rice, mosaic in sugarcane, mosaic in cassava, tristeza in citrus, swollen shoot in cacao, sterility mosaic in pigeonpea, rosette and bud necrosis in peanut, necrosis in sunflower and legumes (vegetables and ornamental crops), leaf curl in cotton and tomato, and ringspot in papaya. Key factors for emergence of new plant virus and virus-like diseases include the intensification of agricultural trade (globalization), changes in cropping systems (crop diversification), and climate change.

In this second volume, the list of plant virus genus and species according to 9th ICTV classification and the latest techniques of plant virus diagnosis are included. In the [Chap. 1](#) along with information on various aspects of ecology and epidemiology

of plant viruses of tropics, we examine the physical and biological factors which are favorable for epiphytotics to develop. Various aspects related to survival and spread of virus and viroids are also presented as well. For an easier understanding of epidemiology, aspects of disease progress curves, mathematical modeling techniques, and systems analysis and simulation models are discussed.

In the **Chap. 2**, comprehensive information on plant virus management are included. The ultimate goal of plant pathologists is to effectively manage the virus and viroid diseases of tropical crops. This topic is quite extensively covered on various relevant aspects including integrated disease management practices. In this chapter, various aspects of disease management like the production of virus-free planting materials through certification schemes for crops like cassava, sweet potato, potato, citrus, banana, grapes, strawberry, pome, stone fruits, ornamental bulbous crops that helps in production of virus-free planting materials are discussed. Similarly, new steps on true seed certification schemes for certain legumes are provided. Cultural practices including rouging, border cropping, plant density, elimination of the virus sources, etc., are discussed. Vector control through the application of insecticides and oils or both are found to be effective in certain virus–host combinations are presented. Available success stories of different horticultural crops with cross-protection techniques are included. Development of pathogen-resistant transgenics for the management of virus and viroid diseases are also added. In the present world globalization, plant quarantines play a major role in almost all countries to exclude the entry of new diseases while importing the germplasm from other countries for research and agricultural purposes.

Information on the key factors of virus epidemiology in certain tropical countries is an important step towards the development of management measures against virus and viroid diseases. Identification of risk factors that contribute to virus outbreaks need to be intensified and integrated disease management (IDM) strategy in reducing the impact of these virus diseases needs to be continued throughout the tropical countries. Nevertheless, integrated control measures have evident benefits and should be fostered and promoted as a means of enhancing crop productivity to meet the increasing demands of burgeoning human population. Originally, the authors have planned to confine to the aspects of virus epidemiology and management of tropical zone only. But to provide more information and clarity of the subject, it was inevitable for us to include the research results of temperate crops also, since some of the crops are grown in both zones.

It is hoped that the information provided in this volume on various aspects of virus and viroid diseases of tropical crops would be useful to research scientists, seed companies, quarantine personnel and institutions of both research and teaching.

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Acronyms

ACMV	<i>African cassava mosaic virus</i>
AMV	<i>Alfalfa mosaic virus</i>
ACLSV	<i>Apple chlorotic leaf spot virus</i>
ApMV	<i>Apple mosaic virus</i>
ASSVd	<i>Apple scar skin viroid</i>
ASGV	<i>Apple stem grooving virus</i>
ASPV	<i>Apple stem pitting virus</i>
ArMV	<i>Arabidopsis mosaic virus</i>
AGVd	<i>Australian grapevine viroid</i>
ASBVd	<i>Avocado sunblotch viroid</i>
BaMV	<i>Bamboo mosaic virus</i>
BBMV	<i>Banana bract mosaic virus</i>
BBTV	<i>Banana bunchy top virus</i>
BSV	<i>Banana streak virus</i>
BaMMV	<i>Barley mild mosaic virus</i>
BSMV	<i>Barley stripe mosaic virus</i>
BYDV	<i>Barley yellow dwarf virus</i>
BaYMV	<i>Barley yellow mosaic virus</i>
BCMV	<i>Bean common mosaic virus</i>
BDMV	<i>Bean dwarf mosaic virus</i>
BGMV	<i>Bean golden mosaic virus</i>
BGYMV	<i>Bean golden yellow mosaic virus</i>
BLRV	<i>Bean leaf roll virus</i>
BPMV	<i>Bean pod mottle virus</i>
BYMV	<i>Bean yellow mosaic virus</i>
BCTV	<i>Beet curly top virus</i>
BMYV	<i>Beet mild yellowing virus</i>
BtMV	<i>Beet mosaic virus</i>
BWYV	<i>Beet western yellows virus</i>
BYNV	<i>Beet yellow net virus</i>
BYV	<i>Beet yellows virus</i>
BYVMV	<i>Bhendi yellow vein mosaic virus</i>
BVY	<i>Blackberry virus Y</i>
BICMV	<i>Black eye cowpea mosaic virus</i>

BMoV	<i>Blackgram mottle virus</i>
BlScV	<i>Blueberry scorch carlavirus</i>
BBSV	<i>Broad bean strain virus</i>
BBWV	<i>Broad bean wilt virus</i>
BMV	<i>Brome mosaic virus</i>
CabLCV	<i>Cabbage leaf curl virus</i>
CaCV	<i>Capsicum chlorosis virus</i>
CdMV	<i>Cardamom mosaic virus</i>
CLV	<i>Carnation latent virus</i>
CarMV	<i>Carnation mottle virus</i>
CNFV	<i>Carnation necrotic fleck virus</i>
CRSV	<i>Carnation ringspot virus</i>
CMoV	<i>Carrot mottle virus</i>
CMDV	<i>Carrot mottley dwarf virus</i>
CTLV	<i>Carrot thin leaf virus</i>
CBSD	<i>Cassava brown streak disease</i>
CBSUV	<i>Cassava brown streak Uganda virus</i>
CBSV	<i>Cassava brown streak virus</i>
CsCMV	<i>Cassava common mosaic virus</i>
CMD	<i>Cassava mosaic disease</i>
CVMV	<i>Cassava vein mosaic virus</i>
CaMV	<i>Cauliflower mosaic virus</i>
CeMV	<i>Celery mosaic virus</i>
CLRV	<i>Cherry leaf roll virus</i>
CMLV	<i>Cherry mottle leaf virus</i>
CRLV	<i>Cherry rasp leaf virus</i>
ChiLCV	<i>Chilli leaf curl virus</i>
CSNV	<i>Chrysanthemum stem necrosis virus</i>
CSVd	<i>Chrysanthemum stunt viroid</i>
CVB	<i>Chrysanthemum virus B</i>
CBLVd	<i>Citrus bent leaf viroid</i>
CDVd	<i>Citrus dwarfing viroid</i>
CEVd	<i>Citrus exocortis viroid</i>
CLBV	<i>Citrus leaf blotch virus</i>
CiLV	<i>Citrus leprosis virus</i>
CMBV	<i>Citrus mosaic badna virus</i>
CiMV	<i>Citrus mosaic virus</i>
CPsV	<i>Citrus psorosis virus</i>
CRSV	<i>Citrus ring spot virus</i>
CTV	<i>Citrus tristeza virus</i>
CVV	<i>Citrus variegation virus</i>
CYMV	<i>Citrus yellow mosaic virus</i>
CIYVV	<i>Clover yellow vein virus</i>
CNV	<i>Cocoa necrosis virus</i>
CSSV	<i>Cocoa swollen shoot virus</i>

CCCVd	<i>Coconut cadang-cadang viroid</i>
CFDV	<i>Coconut foliar decay virus</i>
CoRSV	<i>Coffee ringspot virus</i>
CoYMV	<i>Commelina yellow mottle virus</i>
CLCuV	<i>Cotton leaf curl virus</i>
CABMV	<i>Cowpea aphid borne mosaic virus</i>
CpBMV	<i>Cowpea banding mosaic virus</i>
CCMV	<i>Cowpea chlorotic mottle virus</i>
CpGMV	<i>Cowpea golden mosaic virus</i>
CpMV	<i>Cowpea mosaic virus</i>
CPMoV	<i>Cowpea mottle virus</i>
CPSMV	<i>Cowpea severe mosaic virus</i>
CGMMV	<i>Cucumber green mottle mosaic virus</i>
CMV	<i>Cucumber mosaic virus</i>
CuNV	<i>Cucumber necrosis virus</i>
CPFVd	<i>Cucumber pale fruit viroid</i>
CVYV	<i>Cucumber vein yellowing virus</i>
CABYV	<i>Cucurbit aphid-borne yellows virus</i>
CYSDV	<i>Cucurbit yellow stunt disorder virus</i>
CymMV	<i>Cymbidium mosaic virus</i>
DMV	<i>Dahlia mosaic virus</i>
DsMV	<i>Dasheen mosaic virus</i>
DBV	<i>Dioscorea bacilliform virus</i>
DLV	<i>Dioscorea latent virus</i>
EACMV	<i>East African cassava mosaic virus</i>
EMV	<i>Eggplant mosaic virus</i>
EMDV	<i>Eggplant mottled dwarf virus</i>
EMARaV	<i>European mountain ash ringspot-associated virus</i>
FBNYV	<i>Faba bean necrotic yellows virus</i>
GarMblV	<i>Garlic mite-borne latent virus</i>
GFkV	<i>Grapevine fleck virus</i>
GLRaV	<i>Grapevine leafroll associated virus</i>
GLRV	<i>Grapevine leafroll virus</i>
GVA	<i>Grapevine virus A</i>
GBNV	<i>Groundnut bud necrosis virus</i>
GRSV	<i>Groundnut ring spot virus</i>
GRV	<i>Groundnut rosette virus</i>
HPV	<i>High plains virus</i>
INSV	<i>Impatiens necrotic spot virus</i>
ICMV	<i>Indian cassava mosaic virus</i>
ICRSV	<i>Indian citrus ringspot virus</i>
IPCV	<i>Indian peanut clump virus</i>
IYSV	<i>Iris yellow spot virus</i>
JYMV	<i>Japanese yam mosaic virus</i>
LYSV	<i>Leek yellow stripe virus</i>

LBVV	<i>Lettuce big vein virus</i>
LiYV	<i>Lettuce infectious yellows virus</i>
LMV	<i>Lettuce mosaic virus</i>
LNyV	<i>Lettuce necrotic yellows virus</i>
LSV	<i>Lily symptomless virus</i>
LLV	<i>Lolium latent virus</i>
MacMV	<i>Maclura mosaic virus</i>
MCMV	<i>Maize chlorotic mottle virus</i>
MDMV	<i>Maize dwarf mosaic virus</i>
MMV	<i>Maize mosaic virus</i>
MRFV	<i>Maize rayado fino virus</i>
MRDV	<i>Maize rough dwarf virus</i>
MSV	<i>Maize streak virus</i>
MSpV	<i>Maize stripe virus</i>
MNSV	<i>Melon necrotic spot virus</i>
MYSV	<i>Melon yellow spot virus</i>
MeYVMV	<i>Mesta yellow vein mosaic virus</i>
MLBVV	<i>Mirafiori lettuce big-vein virus</i>
MiLV	<i>Mirafiori lettuce virus</i>
MYMV	<i>Mungbean yellow mosaic virus</i>
OCSV	<i>Oat chlorotic stunt virus</i>
OSDV	<i>Oat sterile dwarf fjiivirus</i>
ORSV	<i>Odontoglossum ringspot virus</i>
OLCV	<i>Okra leaf curl virus</i>
OkMV	<i>Okra mosaic virus</i>
OYVMV	<i>Okra yellow vein mosaic virus</i>
OLV-2	<i>Olive latent virus 2</i>
OYDV	<i>Onion yellow dwarf virus</i>
OrMV	<i>Ornithogalum mosaic virus</i>
OuMV	<i>Ourmia melon virus</i>
PMV	<i>Panicum mosaic virus</i>
PaLCuV	<i>Papaya leaf curl virus</i>
PRSV	<i>Papaya ring spot virus</i>
PYFV	<i>Parsnip yellow fleck virus</i>
PWV	<i>Passion fruit woodiness virus</i>
PEBV	<i>Pea early browning virus</i>
PEMV	<i>Pea enation mosaic virus</i>
PMV	<i>Pea mosaic virus</i>
PSbMV	<i>Pea seed-borne mosaic virus</i>
PLMVd	<i>Peach latent mosaic viroid</i>
PRMV	<i>Peach rosette mosaic virus</i>
PBND	<i>Peanut bud necrosis disease</i>
PBNV	<i>Peanut bud necrosis virus</i>
PCV	<i>Peanut clump virus</i>
PeMoV	<i>Peanut mottle virus</i>

PStV	<i>Peanut stripe virus</i>
PZSV	<i>Pelargonium zonate spot virus</i>
PepMV	<i>Pepino mosaic virus</i>
PMMV	<i>Pepper mild mosaic virus</i>
PMMoV	<i>Pepper mild mottle virus</i>
PeMV	<i>Pepper mottle virus</i>
PepRSV	<i>Pepper ringspot virus</i>
PVBV	<i>Pepper vein banding mosaic virus</i>
PVMV	<i>Pepper veinal mottle virus</i>
PYMV	<i>Pepper yellow mottle virus</i>
PVCV	<i>Petunia vein clearing virus</i>
PPSMV	<i>Pigeon pea sterility mosaic virus</i>
PMWaV	<i>Pineapple mealybug wilt associated virus</i>
PYMoV	<i>Piper yellow mottle virus</i>
PPV	<i>Plum pox virus</i>
PnLV	<i>Poinsettia latent virus</i>
PopMV	<i>Poplar mosaic virus</i>
PAMV	<i>Potato aucuba mosaic virus</i>
PLRV	<i>Potato leaf roll virus</i>
PMTV	<i>Potato mop-top virus</i>
PSTVd	<i>Potato spindle tuber viroid</i>
PVA	<i>Potato virus A</i>
PVC	<i>Potato virus C</i>
PVS	<i>Potato virus S</i>
PVT	<i>Potato virus T</i>
PVX	<i>Potato virus X</i>
PVY	<i>Potato virus Y</i>
PYDV	<i>Potato yellow dwarf virus</i>
PYMV	<i>Potato yellow mosaic virus</i>
PYVV	<i>Potato yellow vein virus</i>
PYV	<i>Potato yellowing virus</i>
PoLV	<i>Pothos latent virus</i>
PDV	<i>Prune dwarf virus</i>
PNRSV	<i>Prunus necrotic ringspot virus</i>
RBDV	<i>Raspberry bushy dwarf virus</i>
RpRSV	<i>Raspberry ringspot virus</i>
RBSDV	<i>Rice black streaked dwarf virus</i>
RDV	<i>Rice dwarf virus</i>
RGSV	<i>Rice grassy stunt virus</i>
RHBV	<i>Rice hoja blanca virus</i>
RNMV	<i>Rice necrosis mosaic virus</i>
RRSV	<i>Rice ragged stunt virus</i>
RSV	<i>Rice stripe virus</i>
RTBV	<i>Rice tungro bacilliform virus</i>
RTSV	<i>Rice tungro spherical virus</i>

RTV	<i>Rice tungro virus</i>
RWSV	<i>Rice wilted stunt virus</i>
RYMV	<i>Rice yellow mottle virus</i>
RGMV	<i>Ryegrass mosaic virus</i>
SDV	<i>Satsuma dwarf virus</i>
SLV	<i>Shallot latent virus</i>
ShVX	<i>Shallot virus X</i>
SBWMV	<i>Soil-borne wheat mosaic virus</i>
SrMV	<i>Sorghum mosaic virus</i>
SACMV	<i>South African cassava mosaic virus</i>
SBMV	<i>Southern bean mosaic virus</i>
SRBSDV	<i>Southern rice black streaked dwarf virus</i>
SbBMV	<i>Soybean blistering mosaic virus</i>
SbCMV	<i>Soybean chlorotic mottle virus</i>
SbDV	<i>Soybean dwarf virus</i>
SMV	<i>Soybean mosaic virus</i>
SSSV	<i>Soybean severe stunt virus</i>
SLCV	<i>Squash leaf curl virus</i>
SqMV	<i>Squash mosaic virus</i>
SqVYV	<i>Squash vein yellowing virus</i>
SLCMV	<i>Srilankan cassava mosaic virus</i>
SCV	<i>Strawberry crinkle virus</i>
SLRSV	<i>Strawberry latent ringspot virus</i>
SMoV	<i>Strawberry mottle virus</i>
SCRLV	<i>Subterranean clover red leaf virus</i>
SCSV	<i>Subterranean clover stunt virus</i>
SBYV	<i>Sugar beet yellows virus</i>
SCFDV	<i>Sugarcane Fiji disease virus</i>
SCMV	<i>Sugarcane mosaic virus</i>
SCSMV	<i>Sugarcane streak mosaic virus</i>
SCYLV	<i>Sugarcane yellow leaf virus</i>
SuCMoV	<i>Sunflower chlorotic mottle virus</i>
SNV	<i>Sunflower necrosis virus</i>
SHMV	<i>Sunn-hemp mosaic virus</i>
SPCSV	<i>Sweet potato chlorotic stunt virus</i>
SPFMV	<i>Sweet potato feathery mottle virus</i>
SPLV	<i>Sweet potato latent virus</i>
SPLCV	<i>Sweet potato leafcurl virus</i>
SPMMV	<i>Sweet potato mild mottle virus</i>
SPMSV	<i>Sweet potato mild speckling virus</i>
SPSVV	<i>Sweet potato sunken vein virus</i>
SPV	<i>Sweet potato virus</i>
SPVD	<i>Sweet potato virus disease</i>
TaBV	<i>Taro bacilliform virus</i>
TEV	<i>Tobacco etch virus</i>

TLCV	<i>Tobacco leaf curl virus</i>
TMGMV	<i>Tobacco Mild Green Mosaic Virus</i>
TMV	<i>Tobacco mosaic virus</i>
TNV	<i>Tobacco necrosis virus</i>
TRV	<i>Tobacco rattle virus</i>
TRSV	<i>Tobacco ring spot virus</i>
TSV	<i>Tobacco streak virus</i>
TStV	<i>Tobacco stunt virus</i>
TVCV	<i>Tobacco vein clearing virus</i>
TVMV	<i>Tobacco vein mottling virus</i>
TASVd	<i>Tomato apical stunt viroid</i>
TAV	<i>Tomato aspermy virus</i>
TBRV	<i>Tomato black ring virus</i>
TBSV	<i>Tomato bushy stunt virus</i>
ToCV	<i>Tomato chlorosis virus</i>
TCSV	<i>Tomato chlorotic spot virus</i>
TGMV	<i>Tomato golden mosaic virus</i>
TICV	<i>Tomato infectious chlorosis virus</i>
ToLCV	<i>Tomato leaf curl virus</i>
ToMV	<i>Tomato mosaic virus</i>
ToMoV	<i>Tomato mottle virus</i>
TPCTV	<i>Tomato pseudo-curly top virus</i>
ToRSV	<i>Tomato ring spot virus</i>
TSWV	<i>Tomato spotted wilt virus</i>
ToTV	<i>Tomato torrado virus</i>
TYLCV	<i>Tomato yellow leaf curl virus</i>
TriMV	<i>Triticum mosaic virus</i>
TBV	<i>Tulip breaking virus</i>
TCV	<i>Turnip crinkle virus</i>
TuMV	<i>Turnip mosaic virus</i>
TYMV	<i>Turnip yellow mosaic virus</i>
ULCV	<i>Urdbean leaf crinkle virus</i>
WBNV	<i>Watermelon bud necrosis virus</i>
WMV	<i>Watermelon mosaic virus</i>
WSMoV	<i>Watermelon silver mottle virus</i>
WSSMV	<i>Wheat spindle streak mosaic virus</i>
WSMV	<i>Wheat streak mosaic virus</i>
WCCV	<i>White clover cryptic virus</i>
WCIMV	<i>White clover mottle virus</i>
WTO	World Trade Organization
WTV	<i>Wound tumor virus</i>
YMMV	<i>Yam mild mosaic virus</i>
YMV	<i>Yam mosaic virus</i>
ZYMV	<i>Zucchini yellow mosaic virus</i>