K. Subramanya Sastry

Plant Virus and Viroid Diseases in the Tropics

Volume 1: Introduction of Plant Viruses and Sub-Viral Agents, Classification, Assessment of Loss, Transmission and Diagnosis

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Foreword

The detection of a *contagium vivum fluidum* associated with a *mosaic* disease of tobacco in Europe at the close of the nineteenth century, was the beginning of a century of major achievements in the advancement of biological sciences. The demonstration in 1937 that *Tobacco mosaic virus* (TMV), was a nucleoprotein, and that its nucleic acid (RNA), contained the genetic information necessary to induce disease in tobacco, set the stage for the advent of genetics, molecular biology, transgenic technology, and the use of viruses as molecular tools. The physicochemical characterization of TMV also lead to the diffusion of modern technologies, such as virus purification (centrifugation), immunology, electrophoresis, electron microscopy, protein and nucleic acid sequencing, and atomic structure of nucleoproteins (X-ray analysis). These developments would eventually make a major contribution to the understanding of the structure of DNA by Watson and Crick in 1953. Finally, these breakthroughs then paved the way to the advent of Molecular Biology, bringing about the greatest revolution in the multiple fields of biological sciences.

However, TMV had a humble origin in the lowlands of tropical South America, where tobacco had been cultivated by the native societies, until the Spanish conquistadores turned it into a commercial export commodity during colonial times. In the nineteenth century, tobacco was being widely grown in Europe as a medicinal plant and, consequently, the stage was set for the emergence of one of the first global epiphytotics of a highly contagious plant virus. In 1887, Dmitri Ivanovsky was sent from the University of Saint Petersburg, the imperial capital of Russia, to investigate a disease affecting tobacco plantations in Ukraine. In 1892, Ivanovsky demonstrated that the causal agent was not excluded by a porcelain filter capable of retaining bacteria, the only known microbial pathogen at that time. In 1898, Martinus Beijerinck confirmed Ivanovsky′s observations in The Netherlands and, thus, the science of Plant Virology was born.

Despite the significant progress made in plant virology in the twentieth century, the detection and characterization of many plant viruses of economic importance remained elusive until the 1980s, particularly in the Tropics, where plant virology facilities were non-existent or very poorly equipped due to the difficult nature of

plant viruses (non-culturable) and lack of the expensive equipments needed to characterize these pathogens up to that decade. Consequently, the early plant virologist had to be thoroughly trained in the various fields of the agricultural sciences: agronomy, genetics, plant breeding, plant physiology, epidemiology, entomology, and plant pathology, in order to manage the viral diseases of crops, often without knowing the causal agent. The advent of molecular biology and the application of molecular techniques, such as the Polymerase Chain Reaction (PCR), to the detection and characterization of plant viruses possessing RNA or DNA genomes, completely changed the field of Plant Virology in the 1980s. All of the sudden, plant virologists only needed partial nucleic acid sequences and a relatively inexpensive PCR machine to detect and identify plant viruses, without the need to visualize, purify, conduct serological assays, or undertake lengthy and complex physicochemical assays to characterize plant viruses. All that was needed to identify viruses was a suitable pair of primers (a strand of nucleic acid that serves as a starting point for DNA synthesis) to obtain partial or total viral genome sequence data to compare to reported viral sequences freely available in databases such as GenBank.

The adoption of molecular techniques not only facilitated research on plant viruses, but it also changed agricultural education and research in areas of critical importance to the science of Plant Virology. Advances in tissue culture techniques, molecular markers, and the genetic manipulation of plant genomes rapidly shifted the attention from traditional plant breeding and traditional virus screening techniques to the promise of selection of virus resistant plant genotypes in molecular biology laboratories using molecular markers. More important, acquiring a basic knowledge in agricultural sciences was no longer required. Instead, a new generation of molecular biologists was formed to deal with any phytopathological problem regardless of the causal organism, be it a fungus, bacterium, or virus. Thus, the new virologist is usually a molecular biologist who chose to work with plant viruses, without former training in agricultural sciences.

Whereas the science of Plant Virology has immensely benefited from the adoption of the new molecular techniques; and conducting plant virus research without a basic working knowledge of molecular biology is no longer possible or desirable in this new millennium, the new generation of molecular virologists need to know the foundations of Plant Virology. Basically, the science of plant pathology, the agronomy of the plant species affected, and the genetic interaction of plant viruses with their plant hosts and vectors. Finally, any virologist must understand how plant viruses are disseminated in nature, and the various control measures available to manage the viral diseases of economically important food and industrial crops. Hence, the importance of a comprehensive book like this one written by Dr. K. Subramanya Sastry, presented in different volumes which describe the nature of plant viruses and viroids, their classification and identification, and the main viral and viroids pathogens that affect food production in the most challenging and dynamic agricultural system in the world: the Tropics.

The virus detection techniques described are completely up-to-date, including the latest molecular techniques developed in the world for the detection and characterization of viruses and viroids in general. The interested readers, professors, and students of agricultural sciences, and specially plant pathologists, will find this publication a complete source of information on the science of Plant Virology in the Tropics.

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Preface

Virus and viroid diseases have become increasingly important constraints to sustainable crop production in the tropical countries. The climatic changes that are occurring throughout the world have impact on plants, vectors, and viruses causing increasing instability within virus–host ecosystems. Some of the threatening and economically important virus diseases in tropical zone which affect the food production 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, clump, and bud necrosis in peanut; necrosis in sunflower and legumes, vegetables, and ornamental crops; yellow mosaic in legumes; leaf curl in cotton and tomato; and ring spot 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.

Largest group of plant viruses exist in the family *Potyviridae* followed by *Geminiviridae* and *Bunyaviridae*. In tropical countries, whitefly transmitted begomoviruses are responsible for heavy crop losses in cassava, cotton, tobacco, tomato, potato, pepper, squash, okra. etc. The tospo- and ilarviruses are wide spread in tropics and affect several important field, horticultural and ornamental crops resulting in serious economic damage in crops like groundnut, sunflower, onion, watermelon, and vegetables like tomato, chillies, and potatoes. Divergence exists in the type of vectors and their population from country to country, for example Hemipterans (aphids, whiteflys, leafhoppers, mealybugs, and others) are the major vectors of plant virus and virus like diseases, comprising more than 80 % of insect-transmitted viruses which represents close to 400 virus species within 39 different genera.

The primary aim of this book is to provide to readers with latest information on different virus and viroid diseases of crops in tropical countries. This volume comprises of five chapters that give an overview of the progress made on virus and viroid diseases of crops of tropics. The first chapter deals with general information on tropics and climate, tropical countries and tropical agriculture; second chapter provides information on viruses, viroids, phytoplasma, and other subviral agents; third chapter on impact of virus and viroid disease on tropical crops; the fourth chapter on various modes of transmission of virus and virus-like agents. Various

methods for detection and diagnosis of viruses and viroid disease of tropical crops are extensively reviewed in the fifth chapter.

Since the inception of plant virology, phytoplasma is dealt along with plant viruses, hence a few pages were devoted in this book for providing background information about phytoplasma for traditional scientists/researchers. Even though the attempt is only to include the examples from tropical zone but it was not possible to confine to tropical examples as successful research outcomes are there from temperate zone; hence, some examples from temperate zone were also referred. If any omissions have occurred inadvertently in seeking permissions for figures and tables, it may please be condoned.

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.

K. Subramanya Sastry

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K. Subramanya Sastry

Acronyms

A1MV	*Alstroemeria mosaic virus*
ABMV	*Azuki bean mosaic virus*
AbMV	*Abaca mosaic potyvirus*
AbMV	*Abutilon mosaic virus*
ACLSV	*Apple chlorotic leaf spot*
ACMV	*African cassava mosaic virus*
AGVd	*Australian grapevine viroid*
AMV	*Alfalfa mosaic virus*
APLV	*Andean potato latent virus*
ApMV	*Apple mosaic virus*
ArMV	*Arabis mosaic virus*
ARSV	*Apple ring spot virus*
ASBVd	*Avocado Sunblotch viroid*
ASGV	*Apple stem grooving virus*
ASPV	*Apple stem pitting virus*
ASSVd	*Apple scar skin viroid*
AYRSV	*Artichoke yellow ring spot virus*
BaMMV	*Barley mild mosaic virus*
BaMV	*Bamboo mosaic virus*
BaYMV	*Barley yellow mosaic virus*
BBMV	*Broad bean mottle virus*
BBrMV	*Banana bract mosaic virus*
BBSV	*Broad bean stain virus*
BBTMV	*Broad bean true mosaic virus*
BBTV	*Banana bunchy top virus*
BBWV	*Broad bean wilt virus*
BCaMV	*Bean calico mosaic virus*
BCMNV	*Bean common mosaic necrotic virus*
BCMV	*Bean common mosaic virus*
BCTV	*Beet curly top virus*
BDBV	*Banana dieback virus*
BDMV	*Bean dwarf mosaic virus*
BGMV	*Bean golden mosaic virus*

BGYMV	*Bean golden yellow mosaic virus*
BICMV	*Black eye cowpea mosaic virus*
BLMV	*Blue berry leaf mottle virus*
BLRV	*Bean leaf roll virus*
BlShV	*Blueberry Shock Ilarvirus*
BMCTV	*Beet mild curly top virus*
BMoV	*Blackgram mottle virus*
BMV	*Brome mosaic virus*
BMYV	*Beet mild yellowing virus*
BNYV	*Broccoli necrotic yellows virus*
BNYVV	*Beet necrotic yellow vein virus*
BPMV	*Bean pod mottle virus*
BRSV	*Beet ringspot virus*
BSGFV	*Banana streak GF virus*
BSMV	*Barley stripe mosaic virus*
BSMV	*Beet stripe mosaic virus*
BSMyV	*Banana streak Mysore virus*
BSOLV	*Banana streak OL virus*
BSUgIV	*Banana streak Uganda I virus*
BSUgLV	*Banana streak Uganda L virus*
BSUgMV	*Banana streak Uganda M virus*
BSV	*Banana streak virus*
BtMV	*Beet mosaic virus*
BWYV	*Beet western yellows virus*
BYDV	*Barley yellow dwarf virus*
BYMV	*Bean yellow mosaic virus*
BYSV	*Bean yellow stipple virus*
BYSV	*Beet yellows stunt virus*
BYV	*Beet yellows virus*
BYVMV	*Bhendi yellow vein mosaic virus*
CABMV	*Cowpea aphid borne mosaic virus*
CaCV	*Capsicum chlorosis virus*
CaMV	*Cauliflower mosaic virus*
CarMV	*Carnation mottle virus*
CBDV	*Colocasia bobone disease virus*
CBMV	*Common bean mosaic virus*
CbMV	*Calibrachoa mottle virus*
CBRV	*Cabbage black ring virus*
CBSV	*Cassava brown streak virus*
CBSUV	*Cassava brown streak Uganda virus*
CbVd-1	*Coleus blumei viroid 1*
CbVd-2	*Coleus blumei viroid 2*

CCCVd	*Coconut cadang–cadang viroid*
CChMVd	*Chrysanthemum chlorotic mottle viroid*
CCMV	*Cowpea chlorotic mottle virus*
CCSV	*Cucumber chlorotic spot virus*
CCSV	*Calla lily chlorotic spot virus*
CCSV	*Cassava Colombian symptomless virus*
CdMV	*Cardamom mosaic virus*
CeMV	*Celery mosaic virus*
CEVd	*Citrus exocortis viroid*
CFDV	*Coconut foliar decay virus*
CFMMV	*Cucumber fruit mottle mosaic virus*
CFSV	*Cassava frogskin virus*
CGMMV	*Cucumber green mottle mosaic virus*
CGMV	*Cassava green mottle virus*
ChiLCV	*Chilli leaf curl virus*
CIBV	*Cassava ivorian bacilliform virus*
CiLV	*Citrus leprosis virus*
CiMV	*Citrus mosaic virus*
CiTLV	*Citrus tatter leaf virus*
CIVV	*Citrus infectious variegation virus*
CLCrV	*Cotton leaf crumple virus*
CLCuAV	*Cotton leaf curl Allahabad virus*
CLCuBV	*Cotton leaf curl Bangalore virus*
CLCuBuV	*Cotton leaf curl Burewala virus*
CLCuKV	*Cotton leaf curl Kokhran virus*
CLCuMV	*Cotton leaf curl Multan virus*
CLCuRV	*Cotton leaf curl Rajasthan virus*
CLCuV	*Cotton leaf curl virus*
CLRV	*Cherry leaf roll virus*
CLVd	*Columnea latent viroid*
ClYMV	*Clover yellow mosaic virus*
ClYVV	*Clover yellow vein* virus
CMBV	*Citrus mosaic badnavirus*
CMDV	*Carrot mottley dwarf virus*
CMV	*Cucumber mosaic virus*
CNV	*Cocao necrosis virus*
CoYMV	*Commelina yellow mottle virus*
CpBMV	*Cowpea banding mosaic virus*
CpCDV	*Chickpea chlorotic dwarf virus*
CpCSV	*Chickpea chlorotic stunt virus*
CPFVd	*Cucumber pale fruit viroid*
CpGMV	*Cowpea golden mosaic virus*
CpMMV	*Cowpea mild mottle virus*
CPMoV	*Cowpea mottle virus*
CpMV	*Cowpea mosaic virus*

CPSMV	*Cowpea severe mosaic virus*
CPsV	*Citrus psorosis virus*
CRSV	*Citrus ring spot virus*
CsALV	*Cassava American latent virus*
CsCMV	*Cassava common mosaic virus*
CSNV	*Chrysanthemum stem necrosis virus*
CSSV	*Cocoa swollen shoot virus*
CSVd	*Chrysanthemum stunt viroid*
CsVX	*Cassava virus X*
CTLV	*Carrot thin leaf virus*
CTV	*Citrus tristeza virus*
CuNV	*Cucumber necrosis virus*
CVMV	*Cassava vein mosaic virus*
CVMV	*Chilli veinal mottle virus* (*Syn. Pepper vein banding mosaic virus*)
CVV	*Citrus variegation virus*
CVYV	*Cucumber vein yellowing virus*
CymMV	*Cymbidium mosaic virus*
CymRSV	*Cymbidium ringspot virus*
CYMV	*Chicory yellow mottle virus*
CYMV	*Citrus yellow mosaic virus*
CYSDV	*Cucurbit yellow stunt disorder virus*
DAV	*Dapple apple virus*
DBV	*Dioscorea bacilliform virus*
DoYMV	*Dolichos yellow mosaic virus*
DsMV	*Dasheen mosaic virus*
EACMCV	*East African cassava mosaic Cameroon virus*
EACMV	*East African cassava mosaic virus*
ELCV	*Enation leaf curl virus*
EMDV	*Eggplant mottled dwarf virus*
EMV	*Eggplant mosaic virus*
FBNYV	*Faba bean necrotic yellows virus*
FLNV	*Freesia leaf necrosis virus*
GBLV	*Grapevine Bulgarian latent virus*
GBNV/PBNV	*Groundnut bud necrosis virus*
GFkV	*Grapevine fleck virus*
GFLV	*Grapevine fan leaf virus*
GLRaV-1	*Grapevine leafroll-associated virus-1*
GLRaV-2	*Grapevine leafroll-associated virus-2*
GLRaV-3	*Grapevine leafroll-associated virus-3*
GLRV	*Grapevine leafroll virus*
GMMV	*Gayfeather mild mottle virus*
GRSPaV	*Grapevine rupestris stem pitting-associated virus*
GRSV	*Groundnut ringspot virus*
GRV	*Groundnut rosette virus*