# Introduction: A Century of Plant Virology in India

1

Bikash Mandal, Govind Pratap Rao, Virendra Kumar Baranwal, and Rakesh Kumar Jain

**Abstract**

Plant viruses are important constraints in Indian Agriculture. There are as many as 168 plant virus species documented in India. The viruses belonging to the genera, *Babuvirus, Badnavirus, Begomovirus, Closterovirus, Cucumovirus, Emaravirus, Ilarvirus, Luteovirus, Macluravirus, Polerovirus, Potyvirus and Tospovirus*, are economically important. The insects, aphid, thrips and whitefly are the important vectors in India. Virus diseases are more problematic in vegetable pulse and fiber crops. The investigation of plant viruses began in India a few years after the discovery of virus. Plant Virology in India has a long and remarkable history. In this book, we bring out the research findings on plant viruses that were carried out in India during the past more than 100 years. The book contains 31 chapters of which 20 are dealt with the characterization of the viruses belonging to 22 genera, one chapter is on viroids, three chapters are on virus vectors, two on diagnosis and four on management of the viruses.

**Keywords**

History • Plant virology • India

## 1.1 Introduction

Viruses are molecular pathogens and infect cellular organisms. They are a unique class of pathogens that are difficult to control. Since the discovery of virus in tobacco mosaic disease at the end of the Nineteenth century in The Netherlands

B. Mandal (✉) • G.P. Rao • V.K. Baranwal • R.K. Jain
Advanced Centre for Plant Virology, Division of Plant Pathology, Indian Agricultural Research Institute, New Delhi 110012, India
e-mail: leafcurl@rediffmail.com



B. Mandal et al. (eds.), *A Century of Plant Virology in India*,
https://doi.org/10.1007/978-981-10-5672-7_1

(Beijerinck 1898), the subject of Plant Virology has considerably evolved during more than the last 100 years. Beside the academic interest, the control of viruses to save the agricultural produces has been a major objective of studies of plant viruses. During 1960–1970, attempts to identify inhibitors of plant viruses as achieved in case of the other pathogens like fungi, were so far largely unsuccessful. Resistant cultivars developed through classical breeding were successfully deployed to manage other pathogens. Although, breeding for resistance against viruses too is considered as the best way to manage them, there are limited sustained successes due to lack of availability of useful sources of resistance and large diversity of rapidly evolving viruses. In the 1980s, the pathogen derived resistance similar to cross protection was demonstrated using genetic engineering approach (Powell et al. 1986). The engineering resistance involving genetic modification of crop plant using parts of virus genome, which is and popularly known as transgenic resistance, has been proved to be successful against numerous viruses and plant species. However, socio-political issues largely discouraged adoption of the transgenic technology in many countries including India. In the present millennium, the study of plant viruses reached the new depth, where the understanding of virus genomics and functional genomics opened up new opportunities to develop better strategies to strengthen the plant's ability to defend against virus infection. However, it is now increasingly understood that the virus disease develops in a plant system following a highly complex network of interactions of plant and viral proteins. In this process, further complexities are added with the interactions with vectors that spread the virus from one plant to another. The tripartite interactions among virus, host plant and vector differ based on the kind of each interacting partners. Gene silencing and identification of interacting protein partners in plant or vector and application of genome editing are emerging areas in the plant virology for achieving resistance in plant. Understanding of the role of micro RNA in virus infection and its modulation of expression has been shown as another emerging approach of prevention of plant virus infection (Pérez-Quintero et al. 2010). It is expected that the 'plant virus medicine' will soon be a reality for the preventive and prophylactic measures against plant virus infection through the topical application of gene silencing therapeutics through nanomaterials (Mitter et al. 2017).

Plant viruses are one of the most important classes of pathogens in Indian Agriculture. The majority of the agricultural areas in India are under the tropical and sub-tropical climate that favours prevalence of viruses and their vectors. The population pressure in India is increasingly influencing intensive cultivation of high-yielding cultivars throughout the year. This provides opportunities to the virus and vectors to establish in an agro-ecosystem challenging the harvest of the full potential of the crop yield. The plant virus diseases in India have evolved as more complex problems simultaneously with the changes in both agriculture system as well as climate. With reference to the development of Plant Virology at global level, the studies of plant viruses in India too have a long and remarkable history.

The investigation of virus diseases in India began a few years after the discovery of virus. The research in Plant Pathology started in India with the establishment of Indian Agricultural Research Institute (IARI) during 1905 in Pusa Bihar. The early

historical account of Plant Pathology in India has been documented (Raychaudhuri et al. 1972). The mosaic or katte of small cardamom (*Elettaria cardamomum*) was perhaps the first virus disease recorded during 1900 in southern India (Mollison 1900), which was later identified as a virus disease based on the transmission by an aphid vector (Uppal et al. 1945).

## 1.2 The Developmental Phages

The first systematic investigation of virus diseases began on sugarcane mosaic during 1922 at IARI, Pusa, Bihar (Dastur 1923). Later, a pioneering work on tobacco leaf curl and its transmission studies through whitefly (*Bemisia tabaci*) was published from IARI (Pal and Tandon 1937; Pruthi and Samuel 1937). During the next two decades, several virus diseases were recorded in cereals, pulses, plantation crops and vegetables. The historical milestones of plant virus research in India have been documented (Raychaudhuri et al. 1972; Sastry and Sai-Gopal 2010).

The research laboratory specifically to conduct plant virus studies was first established in Pune in 1938 by the then Bombay Government in India. Later during 1956, the laboratory was transferred to IARI. In 1950s, IARI was the major research institute to conduct research on plant viruses. During this period, two more research stations on plant virology were created in Shimla and Kalimpong. The Advanced Center for Plant Virology (Fig. 1.1) came into existence in 1988 at IARI, New Delhi, which played an important role in the modern era of Plant Virology in India.

The subject of Plant Virology in India evolved through broadly four distinct eras, (i) The empirical era (1900–1940), when the viral diseases were documented based on the preliminary studies on symptoms and transmission by sap and vector; (ii) the biological era (1940–1970), when studies were conducted mainly on the biological properties such as host range, source of resistance, virus-vector relationships, virus inhibition and disease dissemination; (iii) the serological era (1960–1990), when the emphasis of the work was on virus diagnosis. Among the several methodologies, serology dominated as the most convincing technique for the identification of

**Fig. 1.1** Advanced Centre for Plant Virology at Indian Agricultural Research Institute, New Delhi, the major seat for plant virus research in India

viruses and (iv) the molecular era (1990 onward), when the studies of virus began at genomic level that included isolation of viral nucleic acids, cloning, amplification and sequencing of the gene and genome of viruses. Subsequently, in the recent time, studies were conducted to understand the infectivity of the cloned DNA, transgenic resistance, gene function and host-pathogen interactions at cellular level. The generation of viral genome sequence resources and development of infectious clones of DNA and RNA plant viruses opened up the opportunity to exploit the plant viruses for the useful purposes.

## 1.3 Design and Objectives of the Book

In the ninth report of the International Committee on Taxonomy of Viruses, 1016 virus species and 309 tentative virus species were documented globally. The Indian Plant Virus database has been developed in 2015, which documented 168 plant virus species occurring in India (http://220.227.138.213/virusdb/). Over the past more than 100 years an enormous amount of information was generated in the large body of literature. The objective of this book is to bring this wealth of information in one consolidated platform so as to understand how the subject of Plant Virology evolved in India and how to position the present and the next generation of scientists to deal with the problems of plant viruses in Indian agriculture. The book is designed with the four parts covering characterisation, virus-vectors, diagnosis and management.

*Part I: Virus Characterization* This is the major part of the book that deals with the properties of the viruses. There are 22 articles that describe the virus genera wise accomplishment of research work. The genera of plant viruses included in this part are *Allexivirus, Ampelovirus, Babuvirus, Badnavirus, Begomovirus, Carlavirus, Carmovirus, Closterovirus, Cucumovirus, Emaravirus, Ilarvirus, Luteovirus, Macluravirus, Mandarivirus, Mastrevirus, Pecluvirus, Polerovirus, Potyvirus, Sobemovirus, Tobamovirus, Tospovirus* and *Tungrovirus*. Among all these genera of viruses, the viruses of the genera *Begomovirus* and *Tospovirus* are highly aggressive viral pathogens in many important crops and have the history of recurrent epidemic episodes, and as a result they received maximum attention to research investigation in India. Viroids were discovered in 1971 and the work in India commenced in 1980s. In India, viroids have been identified in citrus, tomato, apple, ornamentals, rubber and grapes. One chapter of the research finding on viroids occurring in India has been included in this part.

*Part II: Virus-Vectors* In the early stage of Plant Virology (1915–1940), several insect vectors were discovered to transmit plant viruses with extraordinary specificity. The vectoring property became an important criterion to differentiate the virus disease from those caused by fungi or bacteria. In India, the first systematic study on the vector transmission was conducted with tobacco leaf curl virus and whitefly. The major virus vectors in India are aphids, whitefly and thrips. This part provides the up-to-date work conducted in India on these important virus-vectors.

*Part III: Virus Diagnosis* Diagnosis of plant viruses gained momentum in 1970 onward when electron microscopy, serology and subsequently nucleic acid based techniques were used for the diagnosis of plant viruses. Research on diagnosis significantly contributed to identification and classification of viruses. Of all the techniques, enzyme-linked immunosorbent assay and polymerase chain reaction were extensively used in diagnosis of viruses. Two chapters one each on serology and nucleic acid based diagnosis approaches were included in this part.

*Part IV: Virus Management* The final aim of understanding plant viruses is to develop strategies to prevent crop yield losses. There is no valid estimate to figure out the losses caused plant viruses in India. However, some viruses are known either to cause crop failure in a season or some causes gradual degradation of the potential yield. Over all, it is perceived that plant viruses are responsible for a significant crop yield losses in India and thus management solutions of viruses are pressing demand of the crop growers and practitioners. This part brings together the different areas of research e.g., conventional approaches, antiviral defence, quarantine and transgenics, that were investigated for the management of virus diseases in India.

## References

Beijerinck MW (1898) Concerning a contagium vivum fluidum as a cause of the spot-disease of tobacco leaves. Verh Akad Wet Amsterdam II(6):3–21

Dastur J (1923) The mosaic disease of sugarcane in India. Agric J India 18:505–509

Mitter N, Worrall EA, Robinson KE, Li P, Jain RG, Taochy C, Fletcher SJ, Carroll BJ, Lu GQ, Xu ZP (2017) Clay nanosheets for topical delivery of RNAi for sustained protection against plant viruses. Nat Plants 3:16207

Mollison JW (1900) Cultivation of the betel palm, cardamom and pepper in the Kanara district of Bombay presidency with notes on the manures used in spice gardens of that tract. Department of Land Record and Agriculture, Bombay. Bulletin No 20, 24 p.

Pal BP, Tandon RK (1937) Types of leaf-curl in Northern India. Indian J Agric Sci 7:363–393

Pérez-Quintero AL, Neme R, Zapata A, López C (2010) Plant microRNAs and their role in defense against viruses: a bioinformatics approach. BMC Plant Biol 10:138

Powell AP, Nelson RS, De B, Hoffmann N, Roger SG, Fraley RT, Beachy RN (1986) Delay of disease development in transgenic plants that express the tobacco mosaic virus coat protein gene. Science 232:738–743

Pruthi HS, Samuel CK (1937) Entomological investigations on the leaf curl diseases of tobacco in North Bihar. I. Transmission experiments with some suspected insect vectors. II An alternate host of the virus and the insect transmitter. Indian J Agric Sci 7:659–670

Raychaudhuri SP, Verma JP, Nariani TK, Sen B (1972) The history of plant pathology in India. Annu Rev Phytopathol 10:21–36

Sastry KS, Sai-Gopal DVR 2010 Glimpses of plant virus research in India. In: Compendium of plant viruses, phytoplasma and viroid diseases research in India (1903–2008). Tirupati: Viology Publication, pp 1–8

Uppal BN, Varma PM, Capoor SP (1945) Mosaic disease of cardamom. Curr Sci 14:208–209