Plant Pathology in the 21st Century

Maria Lodovica Gullino
Gary Munkvold *Editors*

Global Perspectives on the Health of Seeds and Plant Propagation Material

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Volume 6

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Editors
Maria Lodovica Gullino
AGROINNOVA
Università degli Studi di Torino
Grugliasco
Torino
Italy

Gary Munkvold
Plant Pathology and Microbiology
Iowa State University
Ames
Iowa
USA

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Foreword

This volume continues the series of books on "Plant Pathology in the 21st Century", which started in 2010, in cooperation with the International Society for Plant Pathology and contains the papers given at the 10th International Congress of Plant Pathology (ICPP 2013) held in Beijing, August 25–30, 2013 concerning seed health.

The use of healthy seeds and propagation material is a prerequisite in any cropping systems, because it permits to strongly reduce the further adoption of other disease management strategies in the field during the cultivation.

Many pathogens are transmitted throughout infected seeds and propagation material. The fact that propagation material production is very much concentrated in few establishments, favors the quick spread of new diseases throughout seed commercialization. This phenomenon is very much accelerated in a globalized system.

The book covers case studies of contamination, aspects of detection and diagnosis as well as disease management strategies, with special emphasis towards seed treatments with unconventional products.

We believe that, besides representing a written testimony of ICPP 2013, this book will be useful for all plant pathologists as well as students in advanced courses.

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The Editors

Contents

Contributors

Theresa A. S. Aveling University of Pretoria, Pretoria, South Africa

Giorgio M. Balestra Department of Agriculture, Forestry, Nature and Energy, University of Tuscia, Tuscia, Italy

Jianjun Feng Animal & Plant Quarantine Technology Center, Shenzhen, People's Republic of China

Angelo Garibaldi AGROINNOVA, University of Torino, Grugliasco, Italy

Giovanna Gilardi AGROINNOVA, University of Torino, Grugliasco, Italy

Daminen Griessinger European and Mediterranean Plant Protection Organization, Paris, France

M. Lodovica Gullino AGROINNOVA, DISAFA, University of Torino, Grugliasco, Italy

Eckhard Koch Julius Kühn-Institute, Dresden, Germany

Jianqiang Li Department of Plant Pathology, China Agricultural University, Beijing, People's Republic of China

Laixin Luo Department of Plant Pathology, China Agricultural University, Beijing, People's Republic of China

Angelo Mazzaglia Department of Agriculture, Forestry, Nature and Energy, University of Tuscia, Tuscia, Italy

Madeleine McMullen European and Mediterranean Plant Protection Organization, Paris, France

Carmen N. Mortensen Danish Seed Health Centre, Department of Plant and Environmental Sciences, University of Copenhagen, Copenhagen, Denmark

Gary P. Munkvold Seed Science Center, Iowa State University, Ames, IA, USA

Gilberto Olaya Syngenta Crop Protection, Vero Beach, FL, USA

Françoise Petter European and Mediterranean Plant Protection Organization (EPPO), Paris, France

Angelo Porta-Puglia Istituto Sperimentale per la Patologia Vegetale (presently CRA-PAV), Rome, Italy

Steven J. Roberts Plant Health Solutions Ltd, Warwick, UK

Anne-Sophie Roy European and Mediterranean Plant Protection Organization, Paris, France

Sabrina Sarrocco Dipartimento di Scienze Agrarie, Alimentari e Agro-ambientali, Università di Pisa, Pisa, Italy

Norman W. Schaad USDA, ARS, Foreign Disease Weed Science-RU, Ft. Detrick, MD, USA

Thousand Oaks, CA, USA

Monika Scheller Syngenta Crop Protection, Basel, Switzerland

Heather E. Simmons Syngenta Crop Protection, Basel, Switzerland

Muriel Suffert European and Mediterranean Plant Protection Organization, Paris, France

Giovanni Vannacci Dipartimento di Scienze Agrarie, Alimentari e Agro-ambientali, Università di Pisa, Pisa, Italy

Clifford Watrin Syngenta Crop Protection AG, Basel, Switzerland

Ronald Zeun Syngenta Crop Protection, Stein, Switzerland

Part I
General Aspects

Chapter 1
Seed Transmission in the *Potyviridae*

Heather E. Simmons and Gary P. Munkvold

Abstract Viral pathogens comprise approximately half of the emerging diseases in plants, and plant introductions (including the international movement of seed) are considered to be one of the most important contributing factors to the emergence of these pathogens. For the most part plant viruses are incapable of surviving outside of host tissue making their long-term propagation dependent on their hosts. Thus infected seeds are an effective strategy that not only allows for pathogen survival from one season to the next, but also for their dispersal. The *Potyviridae,* as the largest plant virus family, is often considered to be the most economically important and its members rank among the most successful plant pathogens. Seed transmission within the *Potyviridae* family is not uncommon, however the exact mechanism of viral entry into the germ line is currently unknown, and the genetic basis of seed transmission has yet to be completely elucidated. Seed transmission rates are influenced by complex interactions among a variety of factors including the host cultivar, the virus isolate, environmental conditions, the timing of infection, vector characteristics, and viral synergism. Seed transmission can have an enormous effect on the epidemiology of crop pathogens due in part to the ecology of plant viruses which are often secondarily disseminated via insect vectors with the effect that extremely low frequencies of seed transmission can result in devastating epidemics. This is compounded by the fact that vertically infected seedlings often do not exhibit symptoms of viral infection. Given the potential for seed transmitted viral pathogens to initiate epidemics, it is vital to understand how seed transmission rates translate into epidemics. In addition, as seed transmission is a means of dispersal for these viral pathogens, effective phytosanitary measures to control the spread of these pathogens are crucial.

Keywords Epidemiology • Seed infection • Seed-to-seedling transmission • *Potyviridae* • Virus

Given that approximately 90 % of the food crops grown worldwide are propagated from seed (Maude 1996) it is hardly surprising that seed transmitted pathogens

H.E. Simmons • G.P. Munkvold (✉)
Seed Science Center, Iowa State University, Ames, IA 50010, USA
e-mail: munkvold@iastate.edu

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would be a significant concern for both growers and industry alike. Seed transmission is an effective strategy for pathogens, especially viruses, to maintain their populations in host plants. In 1972, K.F. Baker wrote, "Seed transmission is now recognized as the method *par excellence* by which plant pathogens (a) are introduced into new areas, (b) survive periods when the host is lacking, (c) are selected and disseminated as host-specific strains, and (d) are distributed through the plant population as foci of infection" (Baker 1972). Most viruses are unable to survive for any length of time outside host issue, making long-term perpetuation of viruses particularly difficult, especially for those that infect annual plants. Seed infection is an effective mechanism to overcome this, so that the long-term survival of the pathogen is linked to the host (Stacie-Smith and Hamilton 1988). This mechanism allows not only for the survival of the pathogen from one season to the next, but also for the long distance dissemination of the pathogen via infected seed (Albrechtsen 2006). One such example is *Wheat streak mosaic virus* (WSMV) for which phylogenetic studies suggest that the introduction of this virus and its subsequent distribution within Australia was likely via imported seed (Dwyer et al. 2007).

Approximately 20 % of all plant viruses are seed transmitted (Mink 1993), and it is believed that approximately one third of plant viruses will eventually be shown to be seed transmitted (Stacie-Smith and Hamilton 1988). Currently 231 viruses are believed to be seed transmitted (Sastry 2013), with 13 % of these being members of the *Potyviridae* (See Table 1.1 for a list of seed transmitted *Potyviridae*). Among the viruses that infect plants the *Potyviridae* is the largest family, and as a result are often considered to be the most economically important (Berger 2001). This family, and in particular the aphid-transmitted members, are among the most successful plant pathogens (Rybicki and Pietersen 1999). Some of the most important crop pathogens are members of the *Potyviridae*, including *Bean common mosaic virus* (BCMV), *Maize dwarf mosaic virus*, *Lettuce mosaic virus* (LMV), *Plum pox virus* (PPV), *Potato virus Y* (PVY), WSMV, and *Zucchini yellow mosaic virus* (ZYMV) (Berger 2001).

The *Potyviridae* is composed of eight genera: *Brambyvirus*, *Bymovirus*, *Ipomovirus*, *Macluravirus*, *Poacevirus*, *Potyvirus*, *Rymovirus*, and *Tritimovirus*. In addition, there is one as yet unassigned group, which consists of two viruses (*Spartina mottle virus* and *Tomato mild mottle virus*). These genera have a combined total of 203 species with the *Potyvirus* group being the largest, comprising 146 members (International Committee on Taxonomy of Viruses, 2012). The classification is based on shared characteristics; all have positive sense RNA genomes, all save one (*Bymovirus*) are monopartite, and they share a gene order as well as sequence homology. The genomes of all members have a VPg (viral protein genome-linked) covalently linked to the 5′ end and a polyadenylated 3′ end. They also all share the presence of the distinctive pinwheel inclusion bodies of the Cylindrical Inclusion (CI) protein. Genera and species are differentiated based on sequence identity, host range, transmission mode, cytopathology, vector transmission and antigenic properties (King et al. 2012; López-Moya et al. 2001).

Averaged estimates in the late 1990s of worldwide crop losses due to viruses were between 1 and 7 % depending on the crop species (Oerke and Dehne 2004).