

# Contents

Preface .....	vii
Acknowledgement .....	ix
<b>1 Introduction .....</b>	<b>1</b>
1.1 Microbial Plant Pathogens as a Major Limiting Factor of Crop Production .....	1
1.2 Discovery of Viruses and Viroids as Plant Pathogens .....	2
1.3 Detection of Viral and Viroid Plant Pathogens and Disease Diagnosis .....	3
References .....	4
<b>2 Detection of Virus and Viroid Pathogens in Plants .....</b>	<b>7</b>
2.1 Detection of Plant Viruses in Plant Organs .....	8
2.1.1 Plant Virus Taxonomy .....	8
2.1.2 Biological Methods .....	9
2.1.3 Morphological Characteristics .....	20
2.1.4 Physical and Biochemical Techniques .....	25
2.1.5 Immunoassays .....	27
2.1.6 Nucleic Acid-based Techniques .....	64
2.2 Detection of Viroids in Plant Organs .....	123
2.2.1 Molecular Characteristics .....	123
2.2.2 Biological Methods .....	124
2.2.3 Physico-Chemical Methods .....	126
2.2.4 Immunoassays .....	128
2.2.5 Nucleic Acid-based Techniques .....	129
2.3 Detection of Viral Pathogens in Seeds and Planting Materials .....	141
2.3.1 Detection of Viruses in Seeds .....	142
2.3.2 Detection of Viruses in Asexually Propagated Planting Materials .....	152
2.4 Detection of Viroids in Seeds and Planting Materials .....	164
2.4.1 Detection of Viroids in Seeds .....	164
2.4.2 Detection of Viroids in Propagative Planting Materials .....	166

Appendix 1: Detection of Plant Viruses by Different Formats of Enzyme-Linked Immunosorbent Assay (ELISA) (Clark and Adams 1977).....	168
Appendix 2: Detection of <i>Grapevine leaf roll-associated virus-3</i> Using a Single-Chain Fragment Variable Antibody in ELISA (Cogotzi et al. 2009) .....	169
Appendix 3: Detection of <i>Iris yellow spot virus</i> (IYSV) by ELISA Incorporating a Blocking Agent (Smith et al. 2006) .....	170
Appendix 4: Detection of <i>Cucumber mosaic virus</i> (CMV) by Dot Immunobinding Assay (DIBA) (Zein and Miyatake 2009).....	170
Appendix 5: Detection of <i>Tomato spotted wilt virus</i> (TSWV) in Different Tissues of Infected Plants by Tissue Blot Immunoassay (TBIA) (Whitefield et al. 2003).....	171
Appendix 6: Detection of <i>Citrus psorosis virus</i> (CPsV) by Direct Tissue Blot Immunoassay (DTBIA) (Martin et al. 2002).....	172
Appendix 7: Detection of <i>Citrus psorosis virus</i> (CPsV) by Western Blotting Technique (Loconsole et al. 2006).....	172
Appendix 8: Detection of an <i>Ampelovirus</i> by Western Blot Analysis (Valverde et al. 1990; Maliogka et al. 2009).....	173
Appendix 9: Detection of <i>Phalaenopsis</i> Orchid Viruses by Immunoblot Technique (Jan and Yeh 1995; Zheng et al. 2008a,b).....	174
Appendix 10: Detection of <i>Passion fruit woodiness virus</i> (PWV) by Light Microscopic Staining Technique (Jan and Yeh 1995).....	175
Appendix 11: Detection of <i>Potato virus Y</i> (PVY) by Immunohistochemistry Method (Ryang et al. 2004).....	175
Appendix 12: Detection of <i>Grapevine leaf roll-associated virus 3</i> (GLRaV-3) by Electron Microscopic Decoration Technique (Cogotzi et al. 2009).....	175
Appendix 13: Detection of <i>Grapevine fan leaf virus</i> (GFLV) by RT-PCR Assay (Bashir and Hajizadeh 2007) .....	176
Appendix 14: Detection of Strawberry Viruses by Multiplex RT-PCR Assay (Chang et al. 2007) .....	177
Appendix 15: Detection of <i>Pepino mosaic virus</i> (PepMV) by Multiplex One-Step RT-PCR Assay (Alfaro-Fernández et al. 2009) .....	179
Appendix 16: Detection of Orchid Viruses by Multiplex RT-PCR Assay (Lee and Chang 2006).....	180
Appendix 17: Detection of Orchid Viruses by Multiplex RT-PCR Assay Using Simple-Direct-Tube (SDT) Method for RNA Extraction (Suehiro et al. 2005; Yamane et al. 2008) .....	181
Appendix 18: Detection of Pepper Tobamoviruses by Immunocapture (IC)-RT-PCR Assay (Kim et al. 2006) .....	182
Appendix 19: Detection of <i>Florida hibiscus virus</i> by Immunocapture (IC)-RT-PCR Assay (Kamenova and Adkins 2004) .....	183

Appendix 20: Detection of <i>Potato virus Y</i> (PVY) by PCR-ELISA Test (Hataya et al. 1994; Varveri 2000) .....	184
Appendix 21: Detection of <i>Plum pox virus</i> (PPV) by Spot Real-Time PCR Assay (Capote et al. 2009) .....	184
Appendix 22: Detection of <i>Strawberry vein banding virus</i> (SVBV) by Real-Time NASBA Technique (Vašková et al. 2004).....	185
Appendix 23: Detection and Differentiation of <i>Citrus tristeza virus</i> (CTV) Isolates by Single-Strand Conformation Polymorphism Analysis (Sambade et al. 2002) .....	186
Appendix 24: Isolation of ds RNA of Plant Viruses (Zhang et al. 1998).....	186
Appendix 25: Detection of Plant RNA Viruses by Macroarray Technique (Agindotan and Perry 2007).....	187
Appendix 26: Detection of <i>Peach latent mosaic viroid</i> (PLMVd) by Hybridization Techniques (Hadidi et al. 1997) .....	188
Appendix 27: Detection of <i>Coconut cadang-cadang viroid</i> (CCCVd) by Dot Blot Hybridization Technique (Vadamalai et al. 2009) .....	189
Appendix 28: Detection of <i>Coconut cadang-cadang viroid</i> (CCCVd) by Ribonuclease Protection Assay (Vadamalai et al. 2009) .....	191
Appendix 29: Extraction of Citrus Viroids for Multiplex RT-PCR Assay (Wang et al. 2009) .....	191
References .....	192

<b>3 Detection of Viral and Viroid Plant Pathogens in the Environment .....</b>	221
3.1 Detection of Plant Viruses in the Environment.....	222
3.1.1 Detection of Plant Viruses in Soil.....	222
3.1.2 Detection of Plant Viruses in Water.....	229
3.1.3 Detection of Plant Viruses in Air.....	230
3.1.4 Detection of Plant Viruses in Alternative Host Plant Species .....	237
3.2 Detection of Viroids in the Environment.....	241
Appendix 1: Detection of <i>Tobacco ringspot virus</i> (TRSV) in the Nematode Vector by Immunofluorescence Technique (Wang and Gergerich 1998).....	242
Appendix 2: Detection of Plant Viruses in Vector Nematodes by Nested PCR Assay (Martin et al. 2009).....	242
Appendix 3: Detection of <i>Raspberry bushy dwarf virus</i> (RBDV) in the Nematode Vector <i>Longidorus juvenilis</i> by Nested PCR Assay (Pleško et al. 2009) .....	243
Appendix 4: Detection of <i>Polymyxia</i> DNA in the Soil by Real-Time PCR Assay (Ward et al. 2004) .....	244

Appendix 5: Detection of <i>Impatiens necrotic spot virus</i> (INSV) by DAS-ELISA in Thrips Vectors (Sakurai et al. 2004).....	245
Appendix 6: Detection of <i>Citrus tristeza virus</i> RNA Targets by Tissue Squash Real-Time RT-PCR Assay in Aphids (Bertolini et al. 2008).....	245
References .....	246
<b>4 Assessment of Variability in Plant Viral and Viroid Pathogens .....</b>	<b>251</b>
4.1 Assessment of Variability in Plant Viral Pathogens.....	252
4.1.1 Assessment of Variations in Biological Characteristics .....	252
4.1.2 Assessment of Variations in Physico-chemical Characteristics.....	255
4.1.3 Assessment of Variations in Immunological Characteristics.....	256
4.1.4 Assessment of Variations in Genomic Characteristics .....	262
4.2 Assessment of Variability in Viroid Pathogens.....	282
4.2.1 Assessment of Variations in Nucleic Acid Characteristics....	282
Appendix: Differentiation of <i>Peach latent mosaic viroid</i> (PLMVd) Isolates by SSCP Analysis (Xu et al. 2008).....	287
References .....	287
<b>5 Diagnosis of Viral and Viroid Diseases of Plants .....</b>	<b>295</b>
5.1 Choice of Diagnostic Tests for Viral Diseases.....	297
5.1.1 Biological Tests.....	297
5.1.2 Physico-chemical Tests .....	298
5.1.3 Immunoassays.....	299
5.1.4 Nucleic Acid-based Techniques.....	300
5.2 Choice of Diagnostic Tests for Viroid Diseases .....	303
5.2.1 Biological Tests.....	303
5.2.2 Nucleic Acid-based Techniques.....	304
5.3 Agencies Involved in Disease Diagnosis .....	305
5.3.1 Disease Diagnostic Centers .....	306
5.3.2 Plant Quarantines .....	308
References .....	309
<b>Index .....</b>	<b>313</b>