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Plant viruses and viroids released from the NIAS Genebank Project, Japan

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INTRODUCTION

The National Institute of Agrobiological Sciences (NIAS), Japan, is implementing the NIAS Genebank Project for the conservation and promotion of agrobiological genetic resources, which include plants, microorganisms, animals and DNA (excluding lumber and fisheries), to contribute to the development and utilization of agriculture and agricultural products (Nagai *et al*., 2005, 2006; Sato *et al*., 2004a, 2004b; Takeya *et al*., 2011). The collection of microorganism genetic resources in the project mainly consists of fungi and bacteria in terms of number, but also includes plant viruses and viroids. Plant viruses are composed of DNA or RNA, normally wrapped in coats of proteins. Viroids, the molecules of which are less than one-tenth the size of the smallest viruses, are a few hundred nucleobases of highly complementary, circular, single-stranded RNA without the coats of proteins that are typical for viruses. Both plant viruses and viroids are pathogens causing plant diseases, and are economically important because many of them sometimes inflict catastrophic damages on the production of crops, vegetables, flowers and so on in agriculture. Since 1985, the project has also promoted research and preservation of plant viruses and viroids as agrobiological genetic resources. This is the largest such collection in Japan, and has established a reputation for originality and preciousness as well as scale (Anonymous, 2010, 2011). Here, we introduce plant viruses and viroids released from the NIAS Genebank Project.

CLASSIFICATION OF ISOLATES

Plant viruses and viroids in the NIAS Genebank Project have been classified based on their experimental characterization in comparison with information such as reports of the International Committee on Taxonomy of Viruses (ICTV), a committee of the Virology Division of the International Union of Microbiology Societies (IUMS), with the task of developing, refining and maintaining a universal virus taxonomy (Carstens, 2010; Carstens & Ball, 2009; Fauquet *et al*., 2005). As of February 2012, all of the isolates of plant viruses and viroids released from the project are from Japan, totaling 252 and 16, respectively, including ICTV-unassigned species of Butterbur mosaic virus, Amazon lily mild mottle virus, Citrus vein enation virus, Broad bean wilt virus, Tobacco necrosis virus and Citrus viroid original source (Table 1).

Five and two of the viral isolates are the double-stranded DNA virus of *Cauliflower mosaic virus* belonging to *Caulimovirus* of *Caulimoviridae* and the negative sense single-stranded RNA virus of *Tomato spotted wilt virus* belonging to *Tospovirus* of *Bunyaviridae*, respectively. The other 245 viral isolates are the positive sense single-stranded RNA virus, and are divided into 67 species belonging to 25 genera of at least 10 families as follows: *Alphaflexiviridae*, *Betaflexiviridae*, *Bromoviridae*, *Closteroviridae*, *Luteoviridae*, *Potyviridae*, *Secoviridae*, *Tombusviridae*, *Tymoviridae* and *Virgaviridae*. The genera of *Benyvirus* and *Sobemovirus* have not yet been categorized into families by ICTV. The viroid isolates, which are the unencapsidated single-stranded RNA viroid, are divided into 9 species belonging to 4 genera of *Pospiviroidae*.

The viral families with the largest number of genera are *Bromoviridae* (4 genera) and *Secoviridae* (4 genera). Those of species and isolates are *Potyviridae* (*Potyvirus* only/16 species/58 isolates) and *Virgaviridae* (3 genera/9 species/62 isolates), respectively. The viral genus with the largest number of species is *Potyvirus* of *Potyviridae*, and that of isolates is *Tobamovirus* (7 species/58 isolates) of *Virgaviridae*. The viral species with the largest

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Table 1 Classification of plant viruses and viroids released from the project (February 2012)

— Viruses —	NI
Double-stranded DNA	
Caulimoviridae	
Caulimovirus	
Cauliflower mosaic virus	5
Negative sense single-stranded RNA	
Bunyaviridae	
Tospovirus	
Tomato spotted wilt virus	2
Positive sense single-stranded RNA	
Alphaflexiviridae	
Potexvirus	
Alstroemeria virus X	1
Asparagus virus 3	1
Narcissus mosaic virus	1
Nerine virus X	1
Potato virus X	4
Betaflexiviridae	
Capillovirus	
Apple stem grooving virus	1
Carlavirus	
Butterbur mosaic virus[UN]	1
Potato virus M	1
Potato virus S	1
Vitivirus	
Grapevine virus A	3
Grapevine virus B	2
Bromoviridae	
Alfamovirus	
Alfalfa mosaic virus	3
Bromovirus	
Amazon lily mild mottle virus[UN]	1
Cucumovirus	
Cucumber mosaic virus	39
Peanut stunt virus	3
Tomato aspermy virus	2
Apple mosaic virus	1
Asparagus virus 2	1
Closteroviridae	
Ampelovirus	
Grapevine leafroll-associated virus 3	6
Closterovirus	
Citrus tristeza virus	6
Luteoviridae	
Polerovirus	
Citrus vein enation virus[UN]	2
Potyviridae	
Potyvirus	
Alstoroemeria mosaic virus	5
Amazon lily mosaic virus	1
Bean common mosaic virus	4
Bean yellow mosaic virus	2
Carnation vein mottle virus	1
Clover yellow vein virus	4
Dasheen mosaic virus	1
Konjac mosaic virus	2
Lettuce mosaic virus	1
Peanut mottle virus	1
Potato virus A	1
Potato virus Y	5
Soybean mosaic virus	8
Turnip mosaic virus	6
Watermelon mosaic virus	5
Zucchini yellow mosaic virus	11
(continued)	NI
Secoviridae	
Comovirus	
Radish mosaic virus	1
Squash mosaic virus	1
Fabavirus	
Broad bean wilt virus[UN]	1
Broad bean wilt virus 2	6
Gentian mosaic virus	1
Nepovirus	
Arabis mosaic virus	2
Cycas necrotic stunt virus	3
Mulberry ringspot virus	2
Tobacco ringspot virus	1
Tomato ringspot virus	1
Sadwavirus	
Satsuma dwarf virus	1
Tombusviridae	
Carmovirus	
Carnation mottle virus	1
Melon necrotic spot virus	7
Necrovirus	
Olive latent virus 1	2
Olive mild mosaic virus	1
Tobacco necrosis virus[UN]	1
Tombusvirus	
Grapevine Algerian latent virus	1
Tymoviridae	
Maculavirus	
Grapevine fleck virus	1
Virgaviridae	
Hordeivirus	
Barley stripe mosaic virus	2
Tobamovirus	
Cucumber green mottle mosaic virus	7
Kyuri green mottle mosaic virus	3
Odontoglossum ringspot virus	1
Pepper mild mottle virus	4
Tobacco mosaic virus	15
Tomato mosaic virus	27
Youcai mosaic virus	1
Tobravirus	
Tobacco rattle virus	2
Families are undefined.	
Benyvirus	
Beet necrotic yellow vein virus	1
Sobemovirus	
Cocksfoot mottle virus	6
Ryegrass mottle virus	1
Southern bean mosaic virus	2
— Viroids —	
Single-stranded RNA	
Pospiviroidae	
Apscaviroid	
Apple fruit crinkle viroid	1
Apple scar skin viroid	4
Citrus bent leaf viroid	1
Citrus viroid III	1
Citrus viroid original source[UN]	1
Cocadviroid	
Citrus viroid IV	1
Hostuviroid	
Hop stunt viroid	1
Pospiviroid	
Chrysanthemum stunt viroid	5
Citrus exocortis viroid	1

NI: Number of isolates. UN: ICTV-unassigned.

Table 2 List of plant viruses and viroids released from the project by isolation source plant family (February 2012)

— Viruses —	NI
Alstroemeriaceae	
Positive sense single-stranded RNA	
Alphaflexiviridae	
Potexvirus	
Alstroemeria virus X	1
Bromoviridae	
Cucumovirus	
Cucumber mosaic virus	4
Potyviridae	
Potyvirus	
Alstoroemeria mosaic virus	5
Secoviridae	
Fabavirus	
Broad bean wilt virus 2	1
Virgaviridae	
Tobamovirus	
Youcai mosaic virus	1
Amaryllidaceae	
Positive sense single-stranded RNA	
Alphaflexiviridae	
Potexvirus	
Narcissus mosaic virus	1
Bromoviridae	
Bromovirus	
Amazon lily mild mottle virus[UN]	1
Cucumovirus	
Cucumber mosaic virus	2
Potyviridae	
Potyvirus	
Amazon lily mosaic virus	1
Secoviridae	
Nepovirus	
Arabis mosaic virus	1
Tomato ringspot virus	1
Virgaviridae	
Tobravirus	
Tobacco rattle virus	1
Apiaceae	
Positive sense single-stranded RNA	
Secoviridae	
Fabavirus	
Broad bean wilt virus[UN]	1
Araceae	
Positive sense single-stranded RNA	
Potyviridae	
Potyvirus	
Dasheen mosaic virus	1
Konjac mosaic virus	2
Asteraceae	
Negative sense single-stranded RNA	
Bunyaviridae	
Tospovirus	
Tomato spotted wilt virus	1
Positive sense single-stranded RNA	
Betaflexiviridae	
Carlavirus	
Butterbur mosaic virus[UN]	1
Bromoviridae	
Cucumovirus	
Cucumber mosaic virus	2
Tomato aspermy virus	1
(continued)	NI
Potyviridae	
Potyvirus	
Lettuce mosaic virus	1
Secoviridae	
Nepovirus	
Arabis mosaic virus	1
Brassicaceae	
Double-stranded DNA	
Caulimoviridae	
Caulimovirus	
Cauliflower mosaic virus	5
Positive sense single-stranded RNA	
Bromoviridae	
Cucumovirus	
Cucumber mosaic virus	2
Potyviridae	
Potyvirus	
Turnip mosaic virus	6
Secoviridae	
Comovirus	
Radish mosaic virus	1
Virgaviridae	
Tobamovirus	
Tobacco mosaic virus	2
Caryophyllaceae	
Positive sense single-stranded RNA	
Potyviridae	
Potyvirus	
Carnation vein mottle virus	1
Tombusviridae	
Carmovirus	
Carnation mottle virus	1
Bromoviridae	
Cucumovirus	
Cucumber mosaic virus	1
Undefined	
Benyvirus	
Beet necrotic yellow vein virus	1
Cucurbitaceae	
Positive sense single-stranded RNA	
Bromoviridae	
Cucumovirus	
Cucumber mosaic virus	2
Potyviridae	
Potyvirus	
Watermelon mosaic virus	4
Zucchini yellow mosaic virus	11
Secoviridae	
Comovirus	
Squash mosaic virus	1
Tombusviridae	
Carmovirus	
Melon necrotic spot virus	7
Virgaviridae	
Tobamovirus	
Cucumber green mottle mosaic virus	7
Kyuri green mottle mosaic virus	3
Cycadaceae	
Positive sense single-stranded RNA	
Secoviridae	
Nepovirus	
Cycas necrotic stunt virus	1

NI: Number of isolates. UN: ICTV-unassigned.

Table 2 Continued

	NI
Fabaceae	
Positive sense single-stranded RNA	
Bromoviridae	
Alfamovirus	
Alfalfa mosaic virus	3
Cucumovirus	
Cucumber mosaic virus	10
Peanut stunt virus	3
Potyviridae	
Potyvirus	
Bean common mosaic virus	4
Bean yellow mosaic virus	1
Clover yellow vein virus	3
Peanut mottle virus	1
Soybean mosaic virus	8
Watermelon mosaic virus	1
Secoviridae	
Fabavirus	
Broad bean wilt virus 2	1
Nepovirus	
Cycas necrotic stunt virus	1
Undefined	
Sobemovirus	
Southern bean mosaic virus	2
Gentianaceae	
Positive sense single-stranded RNA	
Secoviridae	
Fabavirus	
Broad bean wilt virus 2	1
Gentian mosaic virus	1
Iridaceae	
Positive sense single-stranded RNA	
Bromoviridae	
Cucumovirus	
Cucumber mosaic virus	2
Potyviridae	
Potyvirus	
Bean yellow mosaic virus	1
Secoviridae	
Nepovirus	
Cycas necrotic stunt virus	1
Tobacco ringspot virus	1
Liliaceae	
Positive sense single-stranded RNA	
Alphaflexiviridae	
Potexvirus	
Asparagus virus 3	1
Nerine virus X	1
Bromoviridae	
Ilarvirus	
Asparagus virus 2	1
Tombusviridae	
Necrovirus	
Tobacco necrosis virus[UN]	1
Moraceae	
Positive sense single-stranded RNA	
Secoviridae	
Nepovirus	
Mulberry ringspot virus	2
Orchidaceae	
Positive sense single-stranded RNA	
Virgaviridae	
Tobamovirus	
Odontoglossum ringspot virus	1

(continued)	NI
Plumbaginaceae	
Positive sense single-stranded RNA	
Potyviridae	
Potyvirus	
Clover yellow vein virus	1
Poaceae	
Positive sense single-stranded RNA	
Virgaviridae	
Hordeivirus	
Barley stripe mosaic virus	2
Undefined	
Sobemovirus	
Cocksfoot mottle virus	6
Ryegrass mottle virus	1
Ranunculaceae	
Positive sense single-stranded RNA	
Bromoviridae	
Cucumovirus	
Cucumber mosaic virus	4
Rosaceae	
Positive sense single-stranded RNA	
Betaflexiviridae	
Capillovirus	
Apple stem grooving virus	1
Bromoviridae	
Ilarvirus	
Apple mosaic virus	1
Tombusviridae	
Necrovirus	
Olive latent virus 1	1
Olive mild mosaic virus	1
Closteroviridae	
Closterovirus	
Citrus tristeza virus	6
Luteoviridae	
Polerovirus	
Citrus vein enation virus[UN]	2
Secoviridae	
Sadwavirus	
Satsuma dwarf virus	1
Solanaceae	
Negative sense single-stranded RNA	
Bunyaviridae	
Tospovirus	
Tomato spotted wilt virus	1
Positive sense single-stranded RNA	
Alphaflexiviridae	
Potexvirus	
Potato virus X	4
Betaflexiviridae	
Carlavirus	
Potato virus M	1
Potato virus S	1
Bromoviridae	
Cucumovirus	
Cucumber mosaic virus	10
Tomato aspermy virus	1
Potyviridae	
Potyvirus	
Potato virus A	1
Potato virus Y	5
Secoviridae	
Fabavirus	
Broad bean wilt virus 2	3

Table 2 Continued

Tombusviridae	NI
Necrovirus	
Olive latent virus 1	1
Tombusvirus	
Grapevine Algerian latent virus	1
Virgaviridae	
Tobamovirus	
Pepper mild mottle virus	4
Tobacco mosaic virus	9
Tomato mosaic virus	27
Tobravirus	
Tobacco rattle virus	1
Vitaceae	
Positive sense single-stranded RNA	
Betaflexiviridae	
Vitivirus	
Grapevine virus A	3
Grapevine virus B	2
Closteroviridae	
Ampelovirus	
Grapevine leafroll-associated virus 3	6
Tymoviridae	
Maculavirus	
Grapevine fleck virus	1
Unclear	
Positive sense single-stranded RNA	
Virgaviridae	
Tobamovirus	
Tobacco mosaic virus	4
— Viroids —	NI
Asteraceae	
Single-stranded RNA	
Pospiviroidae	
Pospiviroid	
Chrysanthemum stunt viroid	5
Rosaceae	
Single-stranded RNA	
Pospiviroidae	
Apscaviroid	
Apple fruit crinkle viroid	1
Apple scar skin viroid	4
Rutaceae	
Single-stranded RNA	
Pospiviroidae	
Apscaviroid	
Citrus bent leaf viroid	1
Citrus viroid III	1
Citrus viroid original source[UN]	1
Cocadviroid	
Citrus viroid IV	1
Hostuviroid	
Hop stunt viroid	1
Pospiviroid	
Citrus exocortis viroid	1

number of isolates is *Cucumber mosaic virus* (39 isolates) belonging to *Cucumovirus* of *Bromoviridae*. The viroid genus with the largest number of either species or isolates is *Apscaviroid* (5 species/8 isolates).

Although isolation sources of 4 isolates of *Tobacco mosaic virus* are unclear, the other respective viral isolates are from the plant family of Alstroemeriaceae, Amaryllidaceae, Apiaceae, Araceae, Asteraceae, Brassicaceae, Caryophyllaceae, Cucurbitaceae, Cycadaceae, Fabaceae, Gentianaceae, Iridaceae, Liliaceae, Moraceae, Orchidaceae, Plumbaginaceae, Poaceae, Ranunculaceae, Rosaceae, Solanaceae or Vitaceae (Table 2). Among the viral isolates, the isolates from Solanaceae are the largest and most varied by isolation source. The respective viroid isolates are from the plant family of Asteraceae, Rosaceae or Rutaceae. Among the viroid isolates, the isolates from Rutaceae are the largest and most varied by isolation source.

PROVISION OF ISOLATES WITH INFORMATION

As the NIAS historically has taken over the Genebank Project from the Ministry of Agriculture, Forestry & Fisheries of Japan (MAFF), respective registration numbers of microorganism genetic resources in the project uniformly have the acronym, MAFF, e.g. MAFF104087. All of the viral and viroid isolates, which replicate only in compatible host plant cells, are being maintained by preserving host plant tissues infected with each isolate, according to the following two methods: 1) keeping in storage tanks controlled at −165°C with the vapor phase of liquid nitrogen, and 2) keeping in deep freezers at −80°C after vacuum drying of the tissues in glass ampules without freezing. For the respective isolates, detailed information such as hosts, collection localities, properties, providers to the project, relevant statutes and references as well as the MAFF accession numbers is freely web-accessible through search systems established on databases of the project (http://www.gene.affrc.go.jp/index_en.php), and the glass ampule preparations are usually forwarded to applicants (users) wishing to conduct research or education, based on the project's administrative regulations complying internal and international decisions related to genetic resources of plant viruses and viroids, e.g., the Plant Protection Act (Japan), the Foreign Exchange

& Foreign Trade Control Law (Japan), and the Convention on Biological Diversity (Takeya *et al*., 2011; Tomioka, 2010; Tomioka *et al*., 2009, 2010).

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