**Summary of the 14th IPVE Meeting**
**Seoul, Republic of Korea, May 13-17, 2019**

The 14th International Plant Virus Epidemiology Symposium was held in Seoul, Korea, and hosted by Dr. Peter Palukaitis and Ju-Yeon Yoon. The symposium was attended by 123 participants from 33 countries, and included 12 keynote speeches, 53 oral presentations, and 60 poster presentations. The lectures and presentations provided valuable information regarding recent plant virus epidemiology research from throughout the world. In addition to the meeting, the attendees were treated to a field trip to a Korean folk village and to the Suwon Hwaseong Fortress, providing an opportunity to experience the history and culture of Korea. The ICPVE and meeting organizers are grateful for the support of the Korean Rural Development Administration, and the Korean Society of Plant Pathology who generously provided sponsorship.

**Section 1,2&3. Epidemiology, Ecology, Modeling & Evolution**

<u>James Legg</u>**. Mitigating cassava virus pandemics in an increasingly connected global environment: Lessons from the last 30 years** – Highlighted the importance of producing clean seed systems. Epidemics depend on the distance to cassava because infected because weed reservoirs do not play an important role in epidemics. Importance of phone applications for detection and diagnosis of cassava diseases based on image analysis was presented.
<u>Dirk Janssen</u>**. First natural crossover recombination of intact ORFs between two distinct species of the family *Closteroviridae*** – Described a disease on bean in Almeria, Spain caused by BnYDV, the first crinvirus identified that infects leguminosae. In 2011 BnYDV was no longer present, but a variant of LCV was identified causing the disease that has acquired 2 ORFs from BnYDV, and the transmission and host range properties of BnYDV. This is the first documented natural recombinant virus in the genus Crinivirus.
<u>Cecile Desbiez</u>**. Geographic distribution and evolution of Cucurbitaceae and Solanaceae viruses in the French Mediterranean basin.** Described the recent epidemics in SE France finding that the predominant viruses are WMV, CABYV and CMV in cucurbits and TSWV, PVY, CMV and ToCV in solanaceae, a situation very similar to that from 2004-2008. However, new WMV and CMV variants have been found in the recent years. Aphid-transmitted viruses are much more prevalent in the region than whitefly-transmitted viruses.
<u>Kevin Gauthier</u>**. Ecology of cereal dwarf viruses in an agricultural landscape.** An extensive survey was conducted in grasslands, woods and inhabited areas in Central France finding new host plant species in the family *Poaceae* for BYDV-PAV (<u>four</u> new host species) and for WDV (<u>eight</u> new host species)
<u>John Carr</u>**. Modelling and manipulation of aphid-mediated spread of non-persistently-transmitted viruses.** Explained how viruses alter plant biochemistry and physiology which changes volatile emissions in a way that insect vector behaviour and fitness is also modified. These changes may favor virus spread as shown for CMV. Feeding acceptance/deterrence of aphids on CMV-infected plants varies depending on the host plant species and virus strain. Feeding acceptance may also favor virus spread if there is an increase in the % of winged morphs as shown in mathematical modelling.

**Roger Jones. Epidemiology of zucchini yellow mosaic virus in a tropical irrigation area in Northwest Australia-** An extensive survey was conducted in Northwest Australia where ZYMV is common, identifying the major aphid species driving epidemics and what are the host species for aphid vectors. *A. gossypii, A. craccivora* and *A. nerii* were identified as the major vectors. Cucurbits should be avoided close to sandalwood plantations because they are a good host for *A. craccivora*

**Bill Wintermantel. Detection of a previously unknown virus associated with lettuce dieback disease.** Lettuce dieback was previously demonstrated to be caused by either of two tombusviruses, together with specific environmental conditions, New studies have identified a putative member of the phenuiviridae that is more consistently associated with disease development.

**Alexandra Schoeny. Monitoring aphid population dynamics: towards a better understanding of virus epidemics in melon crops.** Described an 8 yr survey to understand the factors driving epidemics in particular those linked with aphid vectors. She found no significant relationship between aphids and non-persistent viruses (CMV, WMV, ZYMV) but there was a good correlation between *Aphis gossypii* abundance and CABYV epidemics

**Santiago Elena. Variability in resistance genes conditions the evolution of emerging plant RNA viruses.** They explored the role of genetic variability for susceptibility in TEV virulence in a series of evolution experiments. Also, they found that TuMV evolved in *A. thaliana* genotypes that differ in mutations in genes involved in resistance pathways and in genes whose products are essential for potyviruses infection.

**Jan Kreuze. The Peruvian potato virome I: Potato virus Y. The evolution and origin of PVY was discussed for each of the known groups: O, N and C phylogroups.** Much of the present PVY diversity probably emerged after the mid 19th century

**Marilyn Roossinck. Evolution of plant and fungal viruses, and impacts on plant health.** Explored viruses that infect both fungus and plants, explaining how some viruses can have beneficial effects to plants: enhanced resistance to drought or higher resistance to aphids. Could these viruses be used to crossprotect plants against aphid damage?

**Pedro Gomez. Host growth temperature and mixed strain infections alter the population genetic diversity of a plant RNA virus.** He studied how nucleotide variation of pepino mosaic virus populations in two isolates may remain similar in single and mixed infections in plants grown at low temperatures, but high temperatures may alter the genetic variability of the virus populations.

**M. Furuya. Mechanisms underlying intraspecies differentiation of Plantago asiatica mosaic virus isolated from a variety of host plants.** They examined the evolutionary processes shaping the intraspecific diversification of PlAMV using the full-length genome sequences of all 26 isolates of PlAMV including several new isolates in Japan. PlAMV isolates we divided into five clades, which do not correspond to their host plants

**SECTIONS 4, 5 & 6: VIRUS-VECTOR INTERACTIONS & OTHER VECTOR-BORNE DISEASES**

**Kerry Mauck. The ecology of host and vector manipulation by plant viruses: new perspectives on a rapidly expanding field.** – She explained how viruses can manipulate vector behaviour in ways that enhance transmission by vectors, citing several examples in the literature and highlighting the increasing number of papers published in this topic in the past 10 years.

**Alberto Fereres. Novel insights into the transmission of phloem-limited viruses by aphids.** Explained how intracellular punctures in phloem cells associated to the transmission of phloem-limited viruses can be visualized by using electrical penetration graphs (EPG).
**W.W. Liu. ADP ribosylation factor 1 facilitates spread of wheat dwarf virus in its insect vector, *Psammotettix alienus.*** Described how wheat dwarf virus (WDV) circulates in its leafhopper vector *Psammotettix alienus* and the factors involved in virion-vector interaction and virion transport from the gut to the hemocoel.
**Ralf G. Dietzgen. Plant rhabdoviruses – origins, diversity and vector interactions.** Described vector-rhabdovirus interactions and suggests that plant-infecting rhabdoviruses are derived from insect viruses
**Marilyne Uzest. Identification of plant virus receptor candidates in the stylets of their aphid vectors.** Described the cuticular proteins –stylins- located in the acrostyle involved in binding with NC viruses, particularly with CaMV and their likely role in virus transmission by aphids.
**R. Srinivasan. The effects of mixed-viral infections in host plants and in the vector (whitefly) on vector fitness and implications for epidemics.** Explained how mixed infection in different host-plants (squash w/CuLCrV and CYSDV or tomato w/TYLCV) may lead to different behavioural responses to their whitefly vectors.
**Rodrigo Almeida. Ecology of the 'other' vector-borne plant diseases: Similar questions and challenges?** Highlighted that bacterial-vector interactions and epidemiology of bacterial diseases face similar questions and challenges as virus diseases. He explained how vectors of *Xylella fastidiosa* prefer healthy and non-water stressed plants to settle and feed and explained the origin, history and evolution of the different strains recently found in Europe causing disease epidemics
**Ismael Badillo. Analysis of "*Candidatus* Liberibacter solanacearum" haplotype effect on the feeding behaviour of its insect vector, *Bactericera cockerelli.*** Showed that Lso-infected *B. cockerelli* increases salivation in the phloem and reaches the phloem sieve elements faster compared with Lso-free insects- This behaviour would enhance bacterial transmission as shown for many virus-vector interactions.

**SECTIONS 7 & 8: CLIMATE CHANGE & DISEASE CONTROL**

**Piotr Trebicki. Climate change and plant virus epidemiology.** Described how virus incidence and vector fitness and behaviour can be affected in new scenarios of climate change by studying the effects of elevated $CO_2$, temperature and water use efficiency on virus incidence and disease spread. He concluded that changes in host plants induced by climate change will increase BYDV incidence but have a negative impact on their aphid vectors.
**Jan Kreuze. A process-based model of the potato yellow vein virus – *Trialeurodes vaporariorum* (greenhouse whitefly) – potato pathosystem to support risk assessment and surveillance under changing climate.** Used an insect-phenology –degree day- model together with data on temperature-dependent transmission rate to explain the distribution and risk map of the whitefly vector of potato yellow vein virus in South and Central America. Interestingly, transmission rate was maximum at 15ºC and was almost zero below and above the 12-18ºC range. The model predicts that epidemics will increase in higher latitudes and decrease in the tropics
**Amit Gal-In. Development of plant virus resistance by a genome editing approach.** Highlighted the development of virus resistance to potyviruses and tobamoviruses in cucumber and tomato

by utilizing Cas9/sgRNA technology to disrupt the recessive gene function. Also, explained the advantages and constrains of CRISPR/Cas9 –based technology to breed for resistance to plant viruses.

**Lava Kumar. The challenge of yam mosaic virus control: recent advances to contain a persistent virus threat to yam in West Africa.** Described epidemics of the potyvirus, YMV, in West Africa and highlighted how virus-free material reinfected up to 40% in one season due to short-medium range dispersion of non-colonizer aphids that land and transmit the virus. Host plant resistance appears to be the most promising tool for disease management.

**M. Maruthi. Exchanging cassava germplasm for the regional management of two major viral disease epidemics in Eastern and Southern Africa.** Explains that seed cleaning is the best way to manage viral diseases of cassava and the process followed to clean cassava germplasm. About 13% of symptom-free plants were positive by PCR.
**Vasthi Alonso-Chavez. Epidemiological modelling of control strategies against the spread of cassava virus diseases.** Described modelling of Cassava virus diseases based on a short-range dispersal model by their whitefly vector and predicts which is the best timing of control measures.
**Ki Hyun Ryu. Antiviral candidates screening using a viral-GFP vector-based antiviral agent screening system (VAASS) for developing biopesticides.** They found some antiviral candidates derived from plants or fungi showed antiviral activity against PepMoV-Vb1/GFP in plants.

**SECTION 9: DIAGNOSTICS AND SURVEILLANCE**

**Maja Ravnikar,.Application of new diagnostic methods in revealing plant virus transmission pathways and diagnostics.** Use of new technologies for diagnosis and characterization of plant viruses and application of these technologies for concentration and detection of viruses from water.
**JHW Bergervoet. Multiplex detection of pospiviroid plant pathogens.** Development of a multiplexed diagnostic method based on Luminex technology for sensitive detection of all known pospiviroids for use in routine virus indexing was described.
**Jan Kreuze. The Peruvian potato virome II. Potato yellowing virus.** During characterization of the potato virome, an ilarvirus related to fragaria chiloensis latent virus, was identified and several isolates from wild *Solanum* species were characterized.
**Adrian Fox. Making use of historic isolate collections to give context to novel detections from high throughput sequencing.** Historic samples from collections were evaluated with HTS leading to clarification of relationships among viruses and determination of viruses that may be the same as older viruses for which sequence was not available.
**Marleen Botermans. Potential risk of introducing potato (quarantine) viruses by flight passengers.** Potato tubers intercepted at Schippol airport in Amsterdam were found and efforts to reduce this mode of introduction are in process.
**W. Siriwan. Survey and molecular detection of cassava mosaic disease in Thailand.** Described characterization of begomoviruses causing Sri Lankan cassava mosaic virus in Thailand, eradication of the samples and establishment of a monitoring strategy.
**Yubao Zhang. Developing virus assays to improve lily crop production in NW China.** Described immunological tests and demonstrated reliability of immunocapture RT-LAMP assays for detection of lily symptomless virus, cucumber mosaic virus and lily mottle virus, and other viruses affecting lily production in northwestern China.
**Francis Mwatuni. Checking the spread of maize lethal necrosis using modern surveillance and diagnostics tools in Sub-Saharan Africa.** Provided training for surveillance and use of diagnostic tools for Maize lethal necrosis (MLN) in East Africa. Diagnostics in field included immunostrips, coupled with lab analysis using additional molecular and serological techniques. Illustrated changes in MLN incidence showing increase in Uganda, but southern regions remain MLN-free

## SECTION 10: PLANT VIROLOGY IN EAST ASIA

**Sek-Man Wong. Discovery of Hibiscus latent Singapore virus-a familiar tobamovirus that possesses an unfamiliar genome.** Molecular characterization of a tobamovirus from hibiscus and its unique genome characteristics.

**Wilmer Cuellar. Geographical spread of cassava mosaic disease (CMD) and Sri Lankan cassava mosaic virus in Southeast Asia.** Described identification of SLCMV in SE Asia and its distribution, established a diagnostic strategy, identification of alternative hosts, and regional engagement program to enhance communication and efforts for control cassava viruses in SE Asia.

**Ju-Yeon Yoon. Epidemiology and disease control of tomato spotted wilt virus in a chrysanthemum field in South Korea.** Developed a biocontrol strategy against thrips using application of predatory mites to soil and essential oil-based insecticides to leaves, reducing TSWV incidence significantly compared with untreated controls.

**Shinya Tsuda. Emeregence and management of viruses and viroids in 21$^{st}$ century Japan.** Increases in use of imported plants has led to an increase in plant viruses and viroids in Japan. Emergence and spread of introduced viruses, including whitefly-transmitted CCYV, seed and mechanically-transmitteed viroids, and the potyvirus, PPV, in Japan have led to efforts to gain a greater understanding of biology of infections, and efforts for detection and management, and to identify sources of resistance. This illustrates some of the challenges of management of emerging virus diseases in Japan.