International Advances in Plant Virology 2025.

Murcia, Spain. April 8th-11th 2025.

GCRI Travel Grant Recipient:

Jas Atkins, PhD Candidate, University of Warwick and NIAB

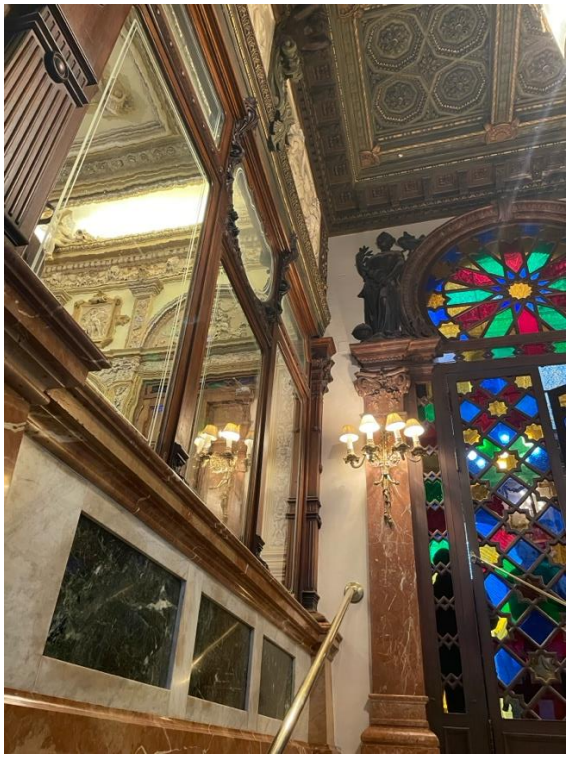
Highlights for the UK protected crops and outdoor ornamental sector

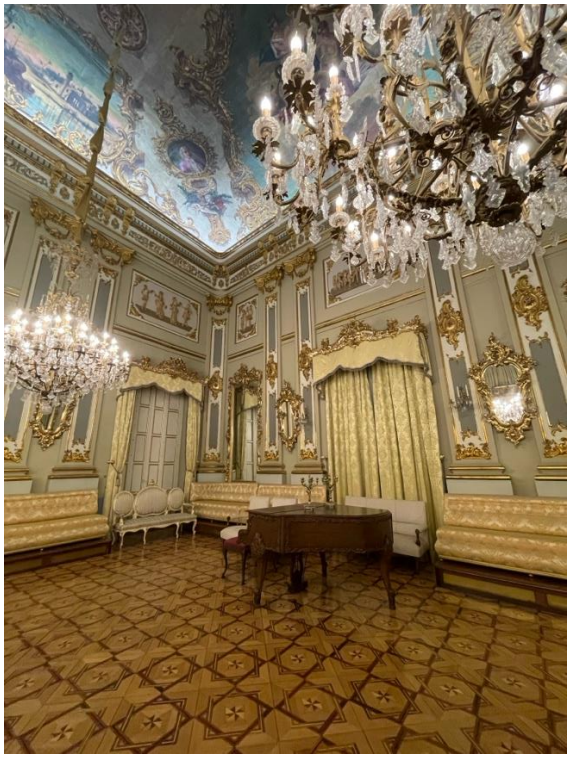
- Insight into the implementation of mitigation strategies for durable disease management of tomatoes and cucurbits through the VIRTIGATION project.
- Exploring water sources, both natural and commercial, as sources of virus transmission.
- New insights into virus epidemiology, utilising viruses of on-demand plant trait reprogramming and the interplay between virus proteins and plants under stress.

Conference Background

Plant viruses are responsible for a significant proportion of devastating emerging and re-emerging plant diseases that lead to global economic losses. The International Advances in Plant Virology (IAPV) conference boasted a broad remit for all scientists interested in plant virology. Over two hundred delegates attended the IAPV conference in Murcia either online or in-person. The main conference was sandwiched between sessions focussed on two collaborative projects. The first of which was the VIRTIGATION project that focusses on developing a broad range of solutions for tomato and cucurbit viruses. The second was VIRNET which aims to encourage knowledge exchange and collaboration among plant virologists.

The main section of the conference was comprised of numerous multifaceted sessions focussing on all aspects of plant virology. These included mechanisms of infection and host responses, virus ecology, transmission and community analyses, virus diagnosis and new research tools as well as viromics and the characterisation of novel viruses. The talks covered a wide variety of crops ranging from tomatoes, sugar-beet, pepper, potatoes, citrus to legumes, trees, aquatic crops and blueberries. Aside from the presentations there were over 100 posters that were displayed at the networking lunches and drinks receptions. The delegates also had the opportunity to attend the conference dinner at El Real Casino de Murcia and admire its unique architecture whilst enjoying some of the best of Murcia's traditional cuisine.





Travel Findings

VIRTIGATION

The VIRTIGATION project is collaborative project with many partners across Europe, with the joint goal of implementing mitigation strategies for durable disease management in tomatoes and cucurbits. The project has specific interest in Begomoviruses, often transmitted by whitefly and Tobamoviruses which are often mechanically transmitted. A specific focus of the session at the conference was for disease management against Tomato brown rugose virus (ToBRFV). ToBRFV is a highly stable, soil-borne Tobamovirus that is a threat to tomato production worldwide and has caused considerable losses in the UK. Symptoms include foliar blistering, mosaic and needle-like deformities as well as rugose, marbling and discolouration of the fruit. It is primarily transmitted through seeds and mechanical contact and therefore robust phytosanitary measures are required in order to effectively manage the virus.

The VIRTIGATION session comprised of six talks looking at different aspects of ToBRFV mitigation strategies, ranging from early identification, soil disinfection, mixed infections, detection in glasshouses and soil and growth-defence tradeoffs. Aviv Dombrovsky from the Volcani Center in Israel and Blanca Sabarit from Fundación Tecnova, Spain spoke about the work they are individually conducting on soil disinfection. Aviv spoke about some of his work looking into the effect of chemical treatments on ToBRFV stability and found that in environments of pH values greater than 10 the virus particles were morphologically altered (when visualised with transmission electron microscopy) and virus infectivity in an experimental setting was abolished. They utilised this knowledge and treated ToBRFV contaminated soil with alkaline chlorinated-trisodium phosphate solution and were able to reduce soil-mediated virus infection of tomato seedlings. Aviv also spoke about the work looking into exploiting the high temperatures of the

mediterranean basin by physical disinfection through solarisation combined with chemical disinfection. Blanca and colleagues have been researching the effects of solarisation and steaming on eliminating Tobacco mosaic virus (TMV), another Tobamovirus closely related to ToBRFV. They conducted their experiments utilising solar radiation to heat soil that was covered with transparent plastic film for 4-6 weeks during the hottest months. They found that the use of solarisation was able to effectively eradicate TMV from 87% of bags containing infected tomato material. Similarly, a collaborator from the Plant Protection Service in Germany conducted steaming experiments at 90 ºC for either 20 minutes in moist conditions or 5 hours in dry conditions. After the steaming treatment, bioassays were regularly conducted for infection and the results indicated that steaming was effective in eradicating TMV.

A section of the VIRTIGATION session that was of particular interest to the UK protected crops sector was a talk entitled ‘Survival and detection of ToBRFV in glasshouse surfaces and soil’ given by Mary Mynett of FERA, York. She detailed how the virus is thought to be able to survive in sap on glasshouse surfaces for at least four weeks and that extended exposure to chemical disinfection or heat is required to deactivate the virus. Mary mentioned how current ToBRFV disinfection approaches that are effective for hydroponic systems are not suitable for soil-based, organic crop systems and that this could place additional pressure on organic production systems following a virus outbreak. Initial work conducted by FERA and other VIRTIGATION partners looking into the risk of direct planting into soil and the viability of the virus in soil and root residues has given interesting results. For tomatoes grown in potting compost mixed substrate it has been shown that the virus can remain biologically active and detectable for over 70 days after the infected plant has been removed. The next step of this work is to see if these results are also applicable to biologically active soil.

The potential role of water sources in virus transmission

An interesting theme that appeared throughout numerous talks in the conference was the role that water sources can have in virus transmission. The first talk that touched on this theme was by Nataša Mehle from the National Institute of Biology, Ljubljana, her talk was entitled ‘Methods of effective early identification and prevention of ToBRFV’. She was able to confirm the presence of ToBRFV RNA in different environmental water samples including wastewater, rivers and irrigation systems. The greenhouse experiments that were conducted indicated that infected plants can release infectious virus particles into water in which they can remain viable for up to four weeks. In addition to this, they also proposed that irrigating tomato crops with ToBRFV contaminated water lead to new infections. Nataša also mentioned that the group are working on potential solutions towards inactivating the virus particles in water.

Another talk focussing on water as a source of virus transmission in both natural and agricultural ecosystems was given by Maja Ravnikar, also from the National Institute of Biology in Ljubljana. Maja spoke about how her group have been working on developing diagnostic methods for the detection of viruses in order to understand virus transmission pathways and their role in the ecosystem by the means of non-invasive surveillance. This expertise helped in tracking new plant viruses and isolates through water source analysis. This information was then able to feed back into the surveillance systems and alert systems in place for plant epidemics. Another result that Maya presented was that some viruses are able to survive passage

through water treatment plants, highlighting the necessity for antimicrobial treatment of the water before it is reused, especially in terms of irrigation or in hydroponic systems.

Lana Vogrinec from the National Institute of Biology, Ljubljana gave a really interesting talk with a focus on the ability of aquatic plants to harbour a diverse range of viruses, including important crop pathogens. She mentioned that very little is known about viruses that can infect aquatic plants despite their widespread presence in the global trade of ornamental plants. Lana spoke about the two-fold approach that was conducted to target this knowledge gap through transcriptomic analyses and high-throughput sequencing of aquatic plant species. The study found numerous viral sequences present in aquatic plants from a wide array of botanical groups. Sequences from known crop pathogens were also noted such as lettuce chlorosis virus and cucumber mosaic virus, as well as novel viral species. One of the key findings of this study was that sequences of begomoviruses, that are regulated within the EU were present in two ornamental aquatic plants.

All of these talks highlight the importance of water, and aquatic plants, as a risk factor for virus transmission and the need for routine monitoring and surveillance of water systems to enhance the early detection of virus infection and help to support preventative measures.

Engineering good viruses to improve crop performance

Another interesting talk was given by Fabio Pasin from the Center for Biological Research in Madrid. He spoke about the work looking into the potential of engineering RNA viruses to deliver nucleic acids, peptides and proteins for plant trait reprogramming. His talk posed interesting points of discussion, particularly why it is safe to administer live recombinant viruses to humans and livestock by vaccination, whereas there are no registered uses of this in crop plants. He also noted that humans and pets can benefit from virus-based gene therapy, but this has not been cleared for crop plants. Also, in the terms of wildlife immunisation, recombinant viruses can be released into the environment but currently not from agricultural crops. Fabio highlighted the potential for utilising virus-based technology for improving Solanaceous cropping systems through on-demand trait reprogramming. The group are currently working on delivering marketable solutions based on plant viruses for agricultural uses.

Recent insights into Tomato fruit blotch virus (ToFBV)

Sabrina Bertin from the Research Centre for Plant Protection and Certification in Rome gave interesting insights into the epidemiology of ToFBV. ToFBV belongs to the Kitaviridae virus family and has been recently identified to cause dimpling, dark spots and uneven, blotchy ripening on tomato fruits. The virus was first identified in 2018-2019 in Italy and Australia and has since had frequent emergence and re-emergence events, resulting in its entry into the EPPO Alert list due to the significant threat it poses to tomato crops worldwide. Recent studies into the replication, translocation and symptomatology have increased the knowledge of the virus and the awareness of the phytosanitary risk it poses. Evidence of the ability of the tomato russet mite (TRM), *Aculops lycopersici,* to acquire and transmit ToFBV from and to tomatoes plants has led to the conclusion that TRMs are the likely vector candidate. The transmission rate observed was moderate to low at around 20% and 50% across two trials but this is likely exacerbated by high TRM population density in

TRM-favourable conditions. Due to the work being conducted and the threat posed by ToFBV it is key that prevention and control measures against both the virus and mites are implemented to avoid severe disease outbreaks.

The role of the C4 protein of Tomato yellow leaf curl Sardinia virus (TYLCSV)

Emanuela Noris from the Institute for Sustainable Plant Protection in Turin gave an insightful talk into the role of the C4 protein of TYLCSV. TYLCSV is a monopartite Begomovirus belonging to the Geminiviridae family. It is able to enhance drought tolerance in tomato plants, potentially due to its C4 protein, through delayed dehydration effects and fast recovery from drought. The group has hypothesised that C4 is able to mediate the reinforcement of cellular barriers within the plan and therefore aid in the interplay between the virus and plants under biotic and abiotic stresses such as drought. Their work has shown that plants overexpressing TYLCSV C4 undergo cell wall remodelling and strong transcriptional deregulation relating to the metabolism of sugar, cell wall components, plant hormones and fatty acids which alter the response of the plant to the pathogen. The groups studies have also shown that the xylem of plants infected with TYLCSV are 30% narrower than uninfected plants and that this is thought to prevent drought effects through possibly limiting excessive water loss.

Personal Statement

I was fortunate enough to attend this conference in the second week of my PhD. I have just started my PhD researching the yield, quality and shelf-life problems in lettuce due to virus infections in the UK. My PhD is hosted at NIAB in Cambridge under the supervision of Dr Charlotte Nellist and registered with the University of Warwick under the supervision of Professors John Walsh and Guy Barker. I am studying my PhD part-time alongside working for a field vegetable agronomy and trials company as a trials and technical coordinator. Attending the IAPV25 in Murcia acted as a great introduction to the international plant virology community and provided me with great insights into the different areas of research being conducted into plant viruses. I will utilise the knowledge gained, and contacts made throughout the course of my PhD and intend to present some of my work at the next meeting.

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If you would like to read more about the talks given at the IAPV that I have mentioned in the report below is a short reference list detailing the papers that some of the presentations were based on:

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