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# International Whitefly Symposium 3

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Professor Peter Klinken officially opened the Symposium. Professor Klinken is the Chief Scientist of Western Australia. He welcomed the delegates to Western Australia and made mention to some of the research work going on in the state and the importance of research and collaboration between different research organisations not only in Australia but also around the world.

## **Dorothy Mukhebi - Engendering a Diversity Lens to Agriculture Prosperity ( Lessons from AWARD )**

AWARD stands for African Women in Agricultural Research and Development and is mostly founded by the Bill and Melinda Gates Foundation. It was setup to address the gender inequality in East Africa. While women makeup 34% of the student population, only 17% of management rolls are women. AWARD provides Fellowships for women to increase their scientific skills and their leadership skills with training occurring not only in Africa but also overseas. Fellowships have been given since 2008 and has proved very successful. They are also working on a more holistic approach, it is not enough to focus on intersections that solely focus on women. They are using a three lens approach (D. Mukhebi, IWS 2018).

1. Gender - Social interactions between male and females
2. Intersectional - Age, Social Class, Race, Ethnicities, Caste, Religion, Sexual Preferences.
3. Institutional

More information can be found at [www.awardfellowships.org](http://www.awardfellowships.org)

## **Biology, Ecology and Invasion Biology:**

### **Peter Sseruwagi - Why it is critical to understand the biology and ecology of Bemisia tabaci in smallholder farming systems.**

Cassava is a staple of the diet in Sub Saharan Africa but is also a major host for Whitefly with some 11-12 generations produced per year. They favour shorter plants over taller ones with peak populations occurring 3 to 6 months after planting, then usually decline. A lot of the population studies have been done at the wrong time of the year after population decline has already occurred. Yield penalties are mostly associated with viruses that are persistently transmitted and are acquired in just six hours. Early infection causes higher yield penalties than latter infection with a lot of new varieties having very poor host plant resistance to both the whitefly and the viruses. Community based programs are needed as farmers have poor education with 91% only having a primary school education level. There is a huge problem translating research to the small landholder. They understand that the viruses are causing the yield damage but don't understand that the whitefly are the vector. Also there is high use of indiscriminate spraying of broad spectrum insecticides coupled with poor spray application. Sources of yield increase are to raise certified seedlings under nets before transplanting to the field.

### **Hadija Ally - What has changed in the outbreaking populations of the severe crop pest whitefly species on cassava in two decades?**

Uganda had outbreaks in the early 1990's. A 2007 - 2017 population study on Cassava in Uganda shows that the whitefly are the Sub Saharan Species with population changing from the sub group SSA2 to SSA1 from 1994 to 2014 and that the diversity of the population has decreased. There are no new populations but it has changed, why? The short answer is they don't know. Reasons put forward for future research are (H. Ally, IWS3 2018):

1. Cassava varieties have changed?
2. Has climate effects caused changes?
3. Chemical applications caused the changes?

**Alana Jacobson - Ecological considerations for designing research questions and sampling plans to investigate the Bemisia tabaci species complex.**

Alana's study was based in New York State, USA and highlighted the importance of getting good abundance data both temporarily and spatially for each host plant including native vegetation. A lot of previous studies have poor monthly abundance data and usually only from the crop the study is about. Very important to know when and where to sample. Alana's conclusions from her study are:

1. Temporal dynamics influence abundance and distribution of species within and among years.
2. Species that are not generally abundant may influence epidemiological and evolutionarily important processes.
3. Vector-virus interactions occur across landscapes.

**Tanya Smith - Silver Leaf Whitefly predation: a DNA approach to its evaluation.**

Tanya Smith's project used specific PCR primers to detect prey DNA in the gut of predators, in this case SLW. Over two years from 2013 to 2015, 230 insect species were collected. From the study Red & Blue Beetles showed to be the best predator followed by Thrip Adults, Flies, Thrip Nymphs, Brown Smudge Bugs and Apple Dimpling Bugs. Importantly previously suggested good Whitefly predators such as the Tangleweb spider group, Minute Pirate Bugs and Big Eyed Bugs did not always test positive for the gut presence of SLW. As such some questions were raised from the study (T. Smith, IWS3 2018).

1. Are these Arthropods less important in cotton cropping?
2. What predation was not detected using molecular assays and is it important?
3. What is impeding the sensitivity of the assay?
4. Is there a more effective and efficient way of using DNA to detect SLW predation.

Also from her study, when exclusion nets were used, there was a 40-60% reduction in SLW Predation. Showing the important work predators do in cotton systems and the importance of IPM.

### **Catherine Gwandu - African Cassava Genotypes Expressing Whitefly Resistance.**

Conclusions from her work in Uganda (C. Gwandu, IWS3 2018):

- Identified Cassava genotypes having potential sources of resistance which could be a valuable resource for future disease resistance breeding programs.
- Field screening should be conducted alongside other screening methods that are not as reliable
- However, field screening serves as a first step to rapidly screen genotypes for susceptibility and resistance.
- Further work is needed to characterise the mechanisms of resistance in Cassava genotypes against whitefly.

### **Rebecca Corkill - Early embryonic development in Bemisia tabaci.**

The study is looking at the potential to control whitefly by controlling the sex genes. Knowledge gained from the study, which involved the eggs being dissected from female whitefly abdomens (MEAM1) and studies using a DAPI method.

- The first stages of embryo development occur inside the Bemisia tabaci abdomen before the egg is laid (unlike for example Drosophila melanogaster)
- Orthologous of sex determination genes of Lepidoptera, Hymenoptera and Diptera are found in Bemisia tabaci.
- The Bemisia tabaci sex determination gene pathway most closely resembles that of Lepidoptera, as opposed to Diptera.

Ongoing work:

- To generate RNA-seq data from individual eggs of different developmental stages in Bemisia tabaci (MEAM1 and MED).

- Identify splice variants of sex-determination genes of Bemisia tabaci (MEAM1 and MED)

(R. Corkill, IWS3 2018)

**Jing Bai - Characterisation of genes encoding small heat shock proteins from Bemisia tabaci and expression under thermal stress.**

## **Whitefly Virus Interactions:**

**Jing Zhao - Proteomic analysis of the interactions between TYLCV CP and its vector proteins reveals the role of TID in constraining viral retention.**

**William Wintermantel - Whitefly transmission, host range, and cloning of a Datura isolate of the torradovirus, tomato necrotic dwarf virus.**

The new Datura isolate is an independent species of the virus which has poor Whitefly transmission and poor mechanical transmission. By using agri clones injected into the plants they were able to get good transmission in Solanaceae species. The Torrado viruses are most likely from coastal Mexico.

Future directions for work (W. Wintermantel, IWS3 2018):

- Simultaneous evaluation of transmission parameters for Tomato Necrotic Dwarf Virus, comparing tomato and Datura isolates
  1. Bemisia tabaci MEAM1, Trialeurodes abutiloneous, Trialeurodes vaporariorum.
  2. Evaluate acquisition, persistence and transmission.
- Evaluate potential for seed transmission of ToNDV in both tomato and Datura stramonium. Studies in progress
- Further evaluate weed reservoirs that may harbour ToNDV to understand the epidemiology of ToNDV in the desert ecosystem.

**Qi Guo - Comparison of transovarial transmission of Tomato Yellow Leaf Curl Virus by seven cryptic species of the Bemisia tabaci whitefly complex indigenous to China.**

They were able to show from the study that TYLCV can cross the Midgut Barrier in Bemisia tabaci into the Haemolymph. It was also shown that there is Vertical transmission in the Invasive species and also that China native species were able to transmit TYLCV vertically. Transovarial transmission efficiency was shown to be between 0 and 70% in eggs

and nymphs with China 1 and MEAM1 species having by far the highest efficiencies. No transmission occurred in young adults but in older adults (11 days old) transmission was shown to occur. Transmission occurred through at least two generations onto healthy plants. MEAM1 also carried over 4 times the quantity of virus in its whole body compared to the native cryptic species within China.

**Renate Krause-Sakate - Performance of Bemisia tabaci MEAM1 and Trialeurodes vaporariorum on healthy and Tomato Chlorosis Virus infected tomato plants and efficiency of virus transmission.**

Conclusions (R. Krause-Sakate, IWS3 2018):

- Healthy tomato plants: *Bemisia tabaci* MEAM1 had a better performance than *T. vaporariorum*. (Greenhouse)
- ToCV-infected tomato plants: *T. vaporariorum* generates more adults and faster than *B. tabaci* MEAM1 - advantage for the first.
- Performance of *T. vaporariorum* is less affected than that of *B. tabaci* MEAM1 when feeding on ToCV-infected tomato plants.
- Virus transmission: *B. tabaci* MEAM1 is a better vector than *T. vaporariorum*.

**Murad Ghanim - Changing a paradigm in plant virus transmission: an aphid-borne polerovirus switches its vector to the whitefly Bemisia tabaci.**

Viruses transmitted in a persistent circulation manner by hemipteran insect groups are usually broken into Aphids transmitting Luteoviridae viruses including Poleroviruses and Whiteflies transmitting the Begomoviruses. Pepper Vein Yellows Virus (PeVYV) has been a Aphid transmitted virus around the world and has been shown to be a recombination of two other Poleroviruses. In Israel in the last two years though they have shown this virus has switched its vector from aphids to whitefly, Bemisia tabaci MEAN1 to be specific.

Summary (M. Ghanim, IWS3 2018):

- Pepper Whitefly-Borne Vein Yellows Virus (PeWBVYV) is the first major whitefly transmitted virus in peppers.
- A first case in which a virus on the genus level has switch its insect vector (among plant, animal and human viruses).
- The B biotype of B. tabaci MEAN1 is, for now, the only vector for the virus, while the Q biotype or aphid species are not vectors.
- Very important implication for many pepper growers: Do they have to move to 50 mesh insect proof greenhouses for preventing whiteflies? Very expensive and might be unrealistic for many! Keeping low low whitefly populations might be more realistic?

**Renate Krause-Sakate - The whitefly transmitted Cowpea Mild Mottle Virus can be an important component to reduce productivity of Soybeans in Brazil.**

In Brazil soybean production consumes some 60 million hectares of land. Cowpea Mild Mottle Virus (CPMMV) has been found in soybeans since 2001. On going research is trying to answer the questions:

- Does reduce yield and by how much?
- Is it seed transmitted? (Probably)
- Do symptomless plants cause reduced production?

**Laura Boykin - Real time portable genome sequencing for global food security.**

Have been trialing portable real time genome sequencing in Sub Saharan Africa. 800 million people depend on Cassava for their daily calories. Cassava in Sub Saharan Africa has been hit hard by viruses with yields potentially dropping from 35-40 T/ha to just 1 T/ha. Normally it takes three months to a year to sequence and report back to the farmers. With this new equipment it can take as little as 33 seconds to sequence a plant and the first trial had the results back to the farmers in 48 hours. This allowed the farmers to remove and destroy plants that contained the virus, even if they showed no signs, and replant with certified stock. Nine months latter they had exceptional yields. The next round of trials was actually done in the field and had the results to the farmers in just 3 hours. A pretty amazing story. More info can be found at [www.cassavavirusactionproject.com](http://www.cassavavirusactionproject.com)

**Monica Kehoe - Unusual occurrence of a DAG motif in the Ipomovirus Cassava Brown Streak Virus:**

In East Africa there are two Ipomoviruses causing huge yield reductions, CBSV (Cassava Brown Streak Virus) and UCBSV (Ugandan Cassava Brown Streak Virus). CBSV is overcoming the cassava immune system and this is making it much harder for breeders to get resistant and even tolerant varieties. Anecdotal evidence and biological studies support UCBSV infected cassava plants, fighting the infection and appear to revert to healthy faster than those infected with CBSV (Maruthi 2015). In transmission studies, *Bemisia tabaci* showed relatively poor transmission rates of 41% for CBSV. While studying whole genomes from samples taken from cassava in Kenya, they found the CBSV samples contained the aphid transmission associated DAG motif but not in UCBSV. This suggests that CBSV is actually most likely to be transmitted by some aphid species. At this point very little is known about the diversity of aphid species in East Africa. Aphids are commonly seen in the field. More research is underway.

## **Whitefly Plant Interactions:**

### **Renate Krause-Sakate - Panoramic situation of whiteflies in Brazil and the efficiency of the different cryptic species to transmit viruses.**

Bemisia tabaci MEAM1 is prevalent in Brazil but since 2015, Brazil has had Bemisia tabaci MED. MEAM1 was never a problem in Sweet Peppers but MED has changed that situation. MED has shown already insecticide resistance and it has proved an excellent transmitter of Brazilian viruses with 90% efficiency compared to around 70% for MEAM1. MEAM1 are clones but MED has many haplotypes. Depending on the host plant one biotype has proved more competitive than the other, except on cotton, where they share it 50:50. Apart from Sweet Peppers, Common Beans have also proved a favorite host for Bemisia tabaci MED.

Conclusions from Renate:

- MEAM1 is still the predominant species in Brazil but MED is spreading to more states.
- MED became a big problem for sweet pepper production in San Paulo State.
- MED is an excellent vector of the main important viruses in Brazil.
- Common Beans: a host that may contribute to the adaption of MED to open fields in Brazil?

### **Latifa Mrisho - Influence of plant-produced volatile chemicals towards host-selection behaviour of the Cassava whitefly Bemisia tabaci.**

Latifa's study asked three questions:

1. Can the cassava whiteflies smell?
2. What chemicals do the whiteflies smell?
3. Which chemicals influence host selection?

Whitefly did have preferences between hosts even with different cassava varieties. Repellant type effects seemed to work, not attractants, with Lemongrass proving to repel male

whitefly. Also whitefly didn't like mite infested plants. Intercropping with repellent plants could prove to be a good strategy for management of whitefly. Traps for whiteflies could also be a tool if attractants can be found.

**Linda Walling - Nymph mortality - a potent mechanism of whitefly resistance in *Medicago sativa* L. (Alfalfa).**

Pursuing Alfalfa's whitefly resistance loci:

- Reliable assay for phenotyping resistance and susceptible alfalfa plants.
- Spectrum of resistance is seen in each population (multigenic trait).
- Using three populations, they have identified two major resistance loci on chromosome 3 and chromosome 8.
- Resistance is not likely conferred by an NLR.
- Resistance is likely to be conferred by two related transcription factors in the center of these loci.
- Resistance to MED is different in resistant alfalfa.

(L Walling, IWS3 2018)

**Simone Heimoana - Indirect whitefly/plant interactions: honeydew related factors affecting cotton lint quality and options for mitigation.**

Summary:

- Australian cotton is a valuable crop with potential pest threats that can diminish lint quality, cause financial losses to growers and damage the good reputation of the industry.
- The best policy is to engage in area wide IPM practices to avoid creating conditions that favour pest spp such as mirids and whiteflies.
- Potential fungicides for prevention of mould under adverse conditions may work as an emergency solution but require further investigation.

(S. Heimoana, IWS3 2018)

**Yolice Tembo - Evaluation of whitefly parasitism on weeds, cassava and other crops in the field.**

Very little work has been done on natural enemies of whitefly (SSA1) and their ecology in Sub Saharan Africa. Found that main parasitism by Aphelinids and that the main parasitoid was *Encarsia sophia*.

## **Management, Control and IPM 1:**

### **Alvin Simmons - Enhancing Watermelon with resistance against Whiteflies:**

- Watermelon really from West Africa not from Southern Africa.
- Comparing Sugar Baby watermelon (has tendrils) to *Citrullus ecirrhosus* (no tendrils and thick leaves)
  - A. Significantly less eggs and adults were found on *C.ecirrhosus* than the Sugar Baby watermelons in choice and no choice assays.
  - B. Significantly less adults emerged from the eggs that were laid on *C.ecirrhosus* compared to those on the Sugar Baby plants

Alvin Simmons Conclusions: (IWS3 2018)

- Can overcome barriers for viable seeds.
- Whitefly performance was suppressed.
- Offers a source of resistance to whiteflies.

### **Peter Ellsworth - Biological control informed thresholds for enhancing IPM of whiteflies in Cotton:**

In 1992 Arizona had a huge whitefly outbreak. It was so bad optometrists had to remove impacted whitefly from eyes. Currently today, 40% of pest managers are either controlling whitefly too late or spraying too early. By studying the food web in cotton in Arizona and their individual impact on whitefly populations he has come up with predator/prey ratios for the biological control of whitefly and hence decision matrices for when to spray or not.

## **Siva Subramaniam - Implementing an IPM program for Silverleaf**

### **Whitefly in vegetables:**

- Bemisia tabaci biotype B became an established pest in horticulture in Queensland in the late 1990's
- Estimated losses in vegetables at \$500 million over 10 years.
- Over the last 13 years implemented IPM strategies
  - Introduction of softer chemistry
  - Parasitoid breeding and releases
  - Field monitoring of pests and beneficials
- With the use of IPM strategies around a 50% reduction in whitefly sprays in vegetables has occurred.

### **Marie Cornett - Audacious insect control approaches for an impatient optimist:**

Global Good managed by Intellectual Ventures and funded by Bill & Melinda Gates Asset Trust. Global Good is a not-for-profit partnership to innovate solutions that address the developing world's greatest needs by opening up new market opportunities for partners and creating meaningful impact to the target population.

Designed and built a human safe laser (Photonic Fence) that can detect and destroy mosquitoes in screen houses with 95% reductions and 87% reductions for Asian Citrus Psyllids. Range of up to 200m with no effect on non target organisms.

Have many other projects in the pipeline.

### **Peter Nimmo - Management of Cowpea Mild Mottle Virus and the whitefly vector in beans:**

In the summer/autumn of 2016, in the Fassifern Valley in South East Queensland, the Carlavirus, Cowpea Mild Mottle Virus was detected in French Bean crops. First detection in Australia in Legumes. The virus was also detected in beans at Bowen in August 2016. The virus was also present in 2017 and 2018 in south Queensland areas.

- CPMMV group is genetically variable and the Queensland isolates do not seem to be closely related to available viral sequences from other countries.

- Lab tests confirmed Whitefly transmission (*Bemisia tabaci* MEAN1) for both both bean and soybean isolates

- Greenhouse inoculation tests showed 20 varieties of French Bean, soybean, cowpea, Mungbeans, Adzuki and Phasey Beans as hosts.

- Chickpea, Lucerne, Peanuts and Tomato's were none hosts.

(P. Nimmo, IWS 2018)

### **Manisha Mishra - Expression of an insecticidal fern protein in cotton protects against whitefly:**

Manisha Mishra from CSIR - Indian Institute of Toxicology Research, Lucknow, India, have successfully transferred a Fern gene into cotton for the control of whitefly. The transgenic cotton plants have provided 100% control of whitefly and hence Cotton Leaf Curl Virus. The plants are non toxic to other insects including beneficials

### **Jamie Hopkinson - Bemisia tabaci insecticide resistance management in Australian Cotton:**

Jamie gave a summary of the resistance increase for Admiral over the last couple of seasons and the strategies the industry put in place to try and combat the increase. Strategies included:

- Tighter application window for Admiral
- Extension work to highlight IPM and the softer approach to early season Mirids
- To highlight the single application only policy
- Annual review process
- Encourage the earlier application of Admiral when canopies are smaller
- Extension efforts with area wide management groups
- CottonInfo videos

### **Siva Subramaniam - Field evaluation of synergists to overcome pyrethroid resistance in Silverleaf Whitefly:**

Siva gave a summary of work done in horticulture in Queensland with the use of PBO's and pyrethroids.

Conclusions:

- Split applications of PBO followed 3-5 hours later with Talstar provided the best results for the control of SLW adults, the greatest reduction in egg numbers, low nymph populations and more marketable fruit.
- Talstar with Enervate and NUQ-3313 provided better SLW control than the equivalent Astound combinations.
- Tank mixtures of Talstar and PBO may be better options for the vegetable industry because of lower costs than split applications.

(S. Subramaniam, IWS3 2018)

### **Mridula Gupta - Knockdown of gut dsRNAses to improve feeding RNAi efficiency of osmoregulatory genes in Bemisia tabaci.**

A very in-depth genetic talk, ( not really for the layman such as me ).

Conclusions:

- Real time PCR analysis revealed enhanced downregulation of target gene in dsRNAses knockdown.
- Downregulation of osmoregulatory genes followed by knockdown of dsRNAses in whitefly showed decreased liquid excretion compared control and sole target gene knockdown as indicated by spots intensity on water sensitive paper
- Study offers proof-of-principle that RNAi efficiency against insect pests can be enhanced by using dsRNA against RNAi-suppressing nuclease genes.

(M. Gupta, IWS3 2018)

## **Systematics and Evolution:**

### **Everlyne Wosula - SNP-genotyping using NextRAD sequencing unravels the genetic diversity of cassava-colonising *Bemisia tabaci*:**

Background:

- Whitefly have over 1000 hosts
- Whitefly transfer over 300 viruses
- 7 known cassava gemini viruses
- 2 brown streak ipomoviruses
- S biotype (Sub Saharan Africa) has 5 haplotypes

Currently a lot of genetic diversity in populations is done by using mitochondrial cytochrome oxidase I (mtCOI). According to (Ballard and Whitlock 2004; Tay et al. 2017) mtCOI has many issues associated with it and is likely to yield insufficient genetic resolution to distinguish populations. NextRAD (Nextera tagmented reductively amplified DNA) is suppose to overcome these deficiencies. Currently using mtCOI the cassava whitefly (*Bemisia tabaci* SSA(Sub Saharan Africa) biotype) is grouped into four major groups SSA1, SSA2, SSA3 and SSA4 with SSA1 being split into five subgroups. From the SNP phylogenetic tree the samples are split into six distinct clusters or groups. These groups are highly geographic and are linked through significant gene flow.

Everlyne's conclusions are:

- Gene flow exists among cassava *B. tabaci* haplogroups.
- Gene flow could lead to emergence of new haplotypes that could greatly alter the spread and severity of CMD (Cassava mosaic disease) and CBSD (Cassava brown streak disease).
  - There is a need to develop robust SNP based diagnostic tools for cassava *B. tabaci*.
  - Genome-wide techniques, such as SNPs, should be used as the basis for *B. tabaci* molecular taxonomy.

**Wee Tak Tay - Quality control of molecular data for defining Bemisia tabaci cryptic species status:**

The work showed that a lot of the previous species/haplotypes/sub-groups in Sub Saharan Africa are flawed and by cleaning up the data he was able to split all the samples into 3 distinct groups which were highly geographical.

**Tonny Kinene - Patterns of conflict between nuclear and mitochondrial cytochrome oxidase I (mtCOI) DNA phylogenies in Bemisia tabaci species complex:**

Tonny's summary of work:

- There are clear conflicting patterns between mtCOI and the 2 nuclear gene topologies.
- MtCOI remains robust in species delimitation when used as a single gene.
- Multiple unlinked loci might be the key in generation of a robust species tree under coalescent-based methods.
- We are going to use 2000 genes to reconstruct a species tree

**Patrick Chikoti - Genetic diversity of mitochondrial DNA of Bemisia tabaci (Gennadius) (Homoptera: Aleyrodidae) associated with Cassava and occurrence of Cassava Mosaic Disease in Zambia:**

Patrick gave a summary of work done in 2013 and 2015 in Zambia showing the varying severity of cassava mosaic disease and the associated whitefly populations across the regions. He concluded by saying "The knowledge of the genetic diversity of Bemisia tabaci species in Zambia is of great practical importance in the light of the recent outbreak of Cassava brown streak disease in the country."

## **Genomes:**

**Navneet Kaur - Common and distinct gene expression changes in whitefly (*Bemisia tabaci*, MEAM1) after feeding on three virus-host plant combinations and whitefly control through RNAi:**

**Peter Atkinson - CRISPR/CAS9-mediated Genome Editing in Whitefly, *Bemisia tabaci*:**

CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats). The project is about genetically engineering Whitefly to control populations. There are many advantages to this technique. The challenge is microinjection of such small eggs requires a “good hand”! New techniques is making genetic engineering of whiteflies possible and cost-effective.

Peter’s Summary:

- Challenging existing techniques for insect embryo micro injection based on the biology of the insect and its host can yield results.
- Optimising a smaller footprint, cost-effective means of rearing whitefly should facilitate the management of genetic strains
- Related areas (plant growth, plant development, plant cell culture) and early papers can yield useful insights.

**Kai-Shu Ling - Genome-wide profiles of miRNAs and piRNAs in whitefly *Bemisia tabaci* in response to feeding on tomato plants infected with Tomato Yellow Leaf Curl Virus:**

Kia-Shu Ling’s Summary:

- A total of 160 miRNAs were identified, 68 being conserved miRNAs and 92 novel miRNAs.
- Approximately 50% of miRNAs correlated inversely with their predicted target transcript expression.
- Between whiteflies that fed on TYLCV infected tomato and non infected tomato, only two miRNAs were significantly different in their expression

- In addition, this is the first report of the genome wide profiling of piRNAs in whiteflies.

- PiRNA clusters in distribution across the whitefly genome. 62% piRNA clusters were derived from non-coding regions, 38% piRNAs from coding genes and transposable elements (TEs).

- These analysis may provide targets for using RNAi and gene editing technologies in whitefly control.

### **Vikas Jindal - Silencing of Vitellogenin Gene in Bemisia tabaci (Gennadius) inhibits fecundity and egg hatching:**

Vitellogenesis is the process of yolk formation via which the nutrients are deposited in the oocyte involved in reproduction. Through silencing of the vitellogenin gene they were able to reduce fecundity, increase egg mortality and increase 1st instar mortality.

### **Peter Sseruwagi - Optimum field sampling of Bemisia tabaci (Gennadius) (Hemiptera: Aleyrodidae) populations: A management decision tool:**

A review of the literature showed that field surveys and sampling of whitefly in East Africa were always carried out in the 'low season', when the populations were lowest. The study involved collecting data every month throughout the year.

Peter's Conclusions for optimal sampling as a management tool:

- Empirical studies:
  - Quantify whitefly abundance and monthly and seasonal dynamics
  - Determine whitefly impact:
    - Population that spreads viral diseases
    - Population that causes physical damage
  - Establish where to screen for whitefly or disease resistance or parasitism.
- Field Surveys:
  - Quantify abundance and geographical distribution, but should be carried out at the appropriate time
  - Determining genetic diversity and distribution of populations

**Latifa Mrisho - NURU, an artificial intelligence system for diagnosis of plant diseases and pests:**

NURU is an app for your phone that can by using the camera on your phone help diagnose plant diseases and then give advice about what to do. It is in a Beta stage of development.

## **Management, Control and IPM 2:**

### **Hazel Parry - Using simulation modelling to inform best management practice for the introduction of whitefly-resistant Cassava varieties:**

Hazel from CSIRO gave a summary of using modelling to inform on how to best introduce whitefly resistant Cassava varieties. The model takes into account such things as crop age, how whitefly populations will respond, percentage uptake of the new varieties in different regions, mechanisms of resistance and management.

### **Richard Sequeira - An overview of Bemisia tabaci (Gennadius) MEAM1 (Silverleaf whitefly) managing Australian Cotton: past, present and future:**

Richard gave an overview of the history of whitefly in the Australian Cotton Industry, from 2001 when outbreaks occurred in Central Queensland through to taking the Arizona experience and management strategy for use in the industry and then adapting the strategy to more fit the Australian situation. Current issues of more southern areas were also raised, as well as having to manage other pests such as Cotton Mealybug and Mirids and the challenges this brings. Also introduced a new strategic framework for SLW management.

### **Vijay Kumar - Managing whitefly, Bemisia tabaci through implementation of Integrated Pest Management in Indian Punjab:**

Vijay gave a summary of the Indian experience with whitefly in cotton through the years culminating with the devastating outbreaks in 2015/16 (Yields went from 543 to 197 kg/ha) and why this outbreak occurred and how the industry responded in the next seasons.

Some of the reasons for the outbreak:

- Mild winter conditions allowing greater survival
- Frequent pre-monsoon showers
- A large number of crop hosts for development
- A delay in planting of the cotton crop by around a month.
- A large number of BT cotton hybrids available from non authorised sources that had limited host plant resistance to whitefly

- Use of broad spectrum insecticides
- Use of sub standard and spurious insecticides
- Use of non authorised and sub standard agro advice
- Neglected cotton fields not destroyed and continued to breed large populations of

Whitefly.

- Poor application of sprays

How did they respond:

• Clean Cultivation and surrounding areas (Intensive chipping of host plants including weeds)

- Use of recommended BT cotton hybrids.
- Ensuring irrigation water was delivered to fields allowing timely planting early.
- Integrated nutrient management for ensuring plant health.
- Regular and intensive industry surveillance for whitefly.
- Use of non chemical (Neem based) and chemical approaches.
- Proper spray Technologies.
- Intensive surveillance of any late sown crops.

### **Solomon Nsumba - Automated whitefly counting - an evaluation of 3 methods:**

Solomon introduced a project and an app to count whitefly on leaves. More information can be found at [mcrops.org](http://mcrops.org).

### **Alizee Taquet - Resistance to insecticides of MEAM1 and IO whitefly species (Hemiptera: Aleyrodidae) in La Reunion:**

Alizee outlined the whitefly situation on La Reunion island in the western Indian Ocean, from the indigenous species described in 1938 through the arrival of *Bemisia tabaci* MEAM1 (B Biotype) and the associated TYLCV (Tomato Yellow Leaf Curl Virus) in the late 1990's to early 2010's with the arrival of *Bemisia tabaci* MED (Q Biotype). The invasive

whitefly species also led to insecticide resistance on the island and virus problems in their main crop, tomatoes.

**Rajagopalbabu Srinivasan - Threats to vegetable production from whitefly-transmitted viruses in the southeastern United States: Insights into whitefly-virus interactions and epidemics:**

The objectives of the project were:

- Examine how TYLCV resistant cultivars influence TYLCV acquisition and inoculation by whiteflies
- Evaluate effects on whitefly fitness
- Speculate their role in TYLCV epidemics

**Peter Gillespie - Situation update on whitefly issues in Australia and SE Asia:**

Peter gave an update on some of issues with whitefly taxonomy/identity both in Australia and especially in South East Asia where little work has been done. He also outlined some of the education programs they are working on in South East Asian countries to try and increase the knowledge base. Peter also talked about some of the whitefly species that are potential biosecurity threats, mostly from South America.

**Summary:**

I wish to thank CCA and CRDC for the opportunity to attend the symposium. It was an intense three days for my brain but was well worth it and I would encourage CCA to continue to provide such opportunities for its members.

Thanks Damien Erbacher