Epidemiology and Management of Whitefly-Transmitted Viruses - A Cross-Industry Workshop

Denis Persley & Cherie Gambley
The Department of Agriculture, Fisheries and Forestry, QLD

Project Number: VM12701
This report is published by Horticulture Australia Ltd to pass on information concerning horticultural research and development undertaken for the melon industry.

The research contained in this report was funded by Horticulture Australia Ltd with the financial support of The Department of Agriculture, Fisheries and Forestry, QLD.

All expressions of opinion are not to be regarded as expressing the opinion of Horticulture Australia Ltd or any authority of the Australian Government.

The Company and the Australian Government accept no responsibility for any of the opinions or the accuracy of the information contained in this report and readers should rely upon their own enquiries in making decisions concerning their own interests.

ISBN 0 7341 3099 6

Published and distributed by:
Horticulture Australia Ltd
Level 7
179 Elizabeth Street
Sydney NSW 2000
Telephone: (02) 8295 2300
Fax: (02) 8295 2399

© Copyright 2013
EPIDEMIOLOGY AND MANAGEMENT OF WHITEFLY-TRANSMITTED VIRUSES – A CROSS-INDUSTRY WORKSHOP

15-17 OCTOBER 2012, ECOSCIENCES PRECINCT, BRISBANE, AUSTRALIA

Denis Persley and Cherie Gambley
Department of Agriculture, Fisheries and Forestry Queensland
Table of contents

Media Summary .................................................................................................................. 2

Introduction ......................................................................................................................... 3

Organising Committee ....................................................................................................... 3

Workshop Program .............................................................................................................. 4

Evaluation of Workshop ..................................................................................................... 6

Key outcomes ..................................................................................................................... 6

Recommendations .............................................................................................................. 7

Acknowledgements ........................................................................................................... 7

Appendix 1 – List of delegates

Appendix 2 – Abstracts
Media summary

A workshop on was held from 15-17 October 2012 on the Epidemiology and management of whitefly-transmitted viruses at the Ecosciences Precinct, Brisbane, Australia. This was the first cross-industry meeting addressing this topic in Australia and had the aims of presenting current knowledge and providing a gap analysis for future activities in whitefly and virus management.

The 56 delegates represented a broad cross section of interests from the cotton, grains, vegetable and nursery industries. Delegates were drawn from research organisations, crop consultants, seed and chemical companies, biosecurity agencies and funding bodies.

There were 24 presentations by Australian speakers and four invited international speakers.

There were also discussion sessions on current and future work areas and management scenarios for dealing with an incursion of cotton leaf curl disease in Australia.

The presentations and discussions emphasized the importance of the begomoviruses which are transmitted by the silverleaf whitefly. The begomovirus Tomato yellow leaf curl was detected in Australia in 2006 and is now a major problem in the Queensland tomato industry.

This group of viruses is a major threat to Australian vegetable, cotton and grain legume industries as a raft of begomoviruses are widespread and damaging throughout Asia and the silverleaf whitefly vector is well established throughout crop production areas in the tropics and sub-tropics of Australia.

As part of the workshop, a seminar for the vegetable industry was organised at Bundaberg on 18 October with the 50 attendees hearing presentations from three international speakers on the management of whitefly and other insect transmitted viruses in vegetable crops in Europe and the USA. A field visit to the Bundaberg production area followed.

Outcomes from the workshop included decisions to develop project applications for the area wide management of whitefly in a vegetable production area and further work on silverleaf whitefly and preparedness of the cotton industry for an incursion of cotton leaf curl disease which is caused by begomoviruses transmitted by the SLW.
Introduction

Whiteflies cause important economic losses through direct feeding damage to a wide range of vegetable, grain legume and fibre crops worldwide. Both the silverleaf whitefly (*Bemisia tabaci*) and the greenhouse whitefly (*Trialeurodes vaporariorum*) have even greater impact as vectors of plant viruses which are causing enormous losses worldwide in vegetable (capsicum, tomato, cucurbit, beans, sweetpotato, lettuce), cotton and grain legume crops. In Australia, Tomato yellow leaf curl virus has become a limiting factor to tomato production in Queensland and Beet pseudoyellows virus is widespread and damaging in greenhouse cucumber crops in several states.

Begomoviruses, transmitted by the silverleaf whitefly, are widespread and damaging throughout Asia and have been identified as a significant biosecurity threat to the Australian vegetable and cotton industries. The incursion of Tomato yellow leaf curl virus in 2006 clearly demonstrated that there are entry and distribution pathways for whitefly transmitted viruses in Australia.

Although the threat posed by whitefly transmitted viruses to Australian crops has been recognized for several years there has not been a meeting of those involved in their detection, surveillance and management. The workshop on the epidemiology and management of whitefly-transmitted viruses was held at the Ecosciences Precinct, Brisbane from 15-17 October 2012. This cross-industry workshop discussed endemic and exotic viral diseases of Australian vegetable, nursery, grains and cotton industries and the biology and management of the whitefly vectors.

Three of the four invited key international experts were able to attend the workshop and these were Dr Bill Wintermantel (USDA, California), Dr Scott Atkins (USDA Florida) and Dr Enrique Moriones (Instituto de Hortofruticultura Subtropical y Mediterránea, Spain). Unfortunately the fourth guest, Dr Rob Briddon (NIBGE, Pakistan), was unable to attend because of complications with his work visa for Pakistan. In addition to these guests, another international plant virologist, Dr Abdel-Salam (Cairo University, Egypt), attended.

Organising team

The organising team for the workshop comprised:

Dr Cherie Gambley, Senior Plant Pathologist, DAFFQ (Chairperson)
David Carey, Senior Horticulturist, DAFFQ
Denis Persley, Principal Plant Pathologist, DAFFQ
Murray Sharman, Senior Plant Pathologist, DAFFQ
Dr Linda Smith, Senior Plant Pathologist, DAFFQ
Dr John Thomas, Principal Research Fellow, Queensland Alliance for Agriculture and Food Innovation, University of Queensland

The committee was assisted by Sally Brown of Sally Brown Conference Connections.
# Workshop Program

## Day 1 - 15th of October

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30</td>
<td>Registration – tea &amp; coffee</td>
<td></td>
</tr>
<tr>
<td>9:00</td>
<td>David Carey</td>
<td>Welcome address</td>
</tr>
<tr>
<td>9:15</td>
<td>Paul De Barro</td>
<td>Simplifying the complex. <em>Bemisia tabaci</em> a not so complex pest</td>
</tr>
<tr>
<td>9:45</td>
<td>Zara Hall</td>
<td>Resistance monitoring for silverleaf whitefly in cotton</td>
</tr>
<tr>
<td>10:00</td>
<td>Richard Sequeira</td>
<td><em>Bemisia tabaci</em>, biotype B (silverleaf whitefly): Ecological and pest management perspectives on an endemic pest in central Queensland</td>
</tr>
<tr>
<td>10:15</td>
<td>Siva Subramaniam</td>
<td>Impact of silverleaf whitefly and challenges in implementing IPM in vegetable crops</td>
</tr>
<tr>
<td>10:30</td>
<td></td>
<td>Morning tea</td>
</tr>
<tr>
<td>11:00</td>
<td>Rob Briddon/ Cherie Gambley</td>
<td>Etiology of cotton leaf curl disease</td>
</tr>
<tr>
<td>11:30</td>
<td>Aly M. Abdel-Salam</td>
<td>Genetic diversity, natural host range, and basis for molecular pathogenesis of begomovirus-satellite DNA complexes in Egypt</td>
</tr>
<tr>
<td>12:00</td>
<td>Rob Briddon/ Andrew Geering</td>
<td>Diversity of begomoviruses of grain legumes across southern Asia</td>
</tr>
<tr>
<td>12:30</td>
<td>Scott Adkins</td>
<td>Ecology and management of whitefly-transmitted vegetable viruses in the southeastern United States</td>
</tr>
<tr>
<td>13:00</td>
<td></td>
<td>Lunch</td>
</tr>
<tr>
<td>14:00</td>
<td>Bill Wintemantel</td>
<td>Emergence and management of whitefly-transmitted viruses affecting melon production in southern California</td>
</tr>
<tr>
<td>14:30</td>
<td>Aly M. Abdel-Salam</td>
<td>Occurrence of <em>Cucurbit yellow stunting disorder virus</em> and <em>Cucumber vein yellowing virus</em> in cucurbits in Egypt</td>
</tr>
<tr>
<td>15:00</td>
<td>Enrique Moroines</td>
<td>Viruses affecting tomatoes grown in protected cropping systems in Spain</td>
</tr>
<tr>
<td>15:30</td>
<td>Aly M. Abdel-Salam</td>
<td>Detection of a begomovirus from sweet potato plants in Egypt</td>
</tr>
<tr>
<td>16:00</td>
<td></td>
<td>Afternoon tea</td>
</tr>
<tr>
<td>16:30</td>
<td>General discussion</td>
<td>Panel</td>
</tr>
<tr>
<td>17:00</td>
<td></td>
<td>Conclusion to the day &amp; house keeping</td>
</tr>
<tr>
<td>17:30 – 19:30</td>
<td></td>
<td>Reception Drinks</td>
</tr>
</tbody>
</table>
### Day 2 – 16th of October

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:30</td>
<td>Tea &amp; coffee</td>
<td></td>
</tr>
<tr>
<td>10:30</td>
<td>John Thomas</td>
<td><em>Tomato yellow leaf curl virus</em> in Australia: distribution &amp; resistance breeding</td>
</tr>
<tr>
<td>11:00</td>
<td>Denis Persley</td>
<td>Viruses affecting vegetables grown under protected cropping systems (BPYV &amp; ToTV) in Australia</td>
</tr>
<tr>
<td>11:30</td>
<td>Morning tea</td>
<td></td>
</tr>
<tr>
<td>12:00</td>
<td>Bill Wintermannel</td>
<td>Insect-transmitted viruses affecting tomato production in western North America.</td>
</tr>
<tr>
<td>12:30</td>
<td>Enrique Moroines</td>
<td>Control of whitefly-transmitted viruses affecting tomatoes grown in protected cropping systems in Spain</td>
</tr>
<tr>
<td>13:00</td>
<td>Rob Briddon/Cherie Gambley</td>
<td>Management of Begomovirus diseases</td>
</tr>
<tr>
<td>13:30</td>
<td>Lunch</td>
<td></td>
</tr>
<tr>
<td>14:30</td>
<td>Nancy Shellhorn</td>
<td>Colonization of <em>Bemisia tabaci</em> and <em>Eretmocerus hayati</em> at multiple spatial scales: Does the landscape context matter?</td>
</tr>
<tr>
<td>15:00</td>
<td>Hugh Brier</td>
<td>Control of SLW without insecticides: the grains approach</td>
</tr>
<tr>
<td>15:30</td>
<td>Lewis Wilson</td>
<td>Emerging pests and silver leaf whitefly; a challenge for Australian cotton systems</td>
</tr>
<tr>
<td>16:00 –</td>
<td>Afternoon tea &amp; Discussion</td>
<td>Panel: Key areas where data is missing</td>
</tr>
<tr>
<td>19:00 –</td>
<td>Workshop dinner</td>
<td></td>
</tr>
</tbody>
</table>

### Management strategies: International: Chair Grant Smith

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:00</td>
<td>Bill Wintermannel</td>
<td>Insect-transmitted viruses affecting tomato production in western North America.</td>
</tr>
<tr>
<td>12:30</td>
<td>Enrique Moroines</td>
<td>Control of whitefly-transmitted viruses affecting tomatoes grown in protected cropping systems in Spain</td>
</tr>
<tr>
<td>13:00</td>
<td>Rob Briddon/Cherie Gambley</td>
<td>Management of Begomovirus diseases</td>
</tr>
<tr>
<td>13:30</td>
<td>Lunch</td>
<td></td>
</tr>
</tbody>
</table>

### Management strategies: National: Chair Len Tesoriero

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:30</td>
<td>Nancy Shellhorn</td>
<td>Colonization of <em>Bemisia tabaci</em> and <em>Eretmocerus hayati</em> at multiple spatial scales: Does the landscape context matter?</td>
</tr>
<tr>
<td>15:00</td>
<td>Hugh Brier</td>
<td>Control of SLW without insecticides: the grains approach</td>
</tr>
<tr>
<td>15:30</td>
<td>Lewis Wilson</td>
<td>Emerging pests and silver leaf whitefly; a challenge for Australian cotton systems</td>
</tr>
<tr>
<td>16:00 –</td>
<td>Afternoon tea &amp; Discussion</td>
<td>Panel: Key areas where data is missing</td>
</tr>
<tr>
<td>19:00 –</td>
<td>Workshop dinner</td>
<td></td>
</tr>
</tbody>
</table>

### Day 3 – 17th of October

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30</td>
<td>Tea &amp; coffee</td>
<td></td>
</tr>
<tr>
<td>9:00</td>
<td>Sharon Van Brunschot</td>
<td>New technologies for the multiplexed detection of begomoviruses and their whitefly vectors</td>
</tr>
<tr>
<td>9:30</td>
<td>Jo Slattery</td>
<td>Contingency planning for whitefly transmitted viruses in the nursery industry</td>
</tr>
<tr>
<td>9:45</td>
<td>Cherie Gambley</td>
<td>Preparedness for CLCuD in Australian cotton</td>
</tr>
<tr>
<td>10:00</td>
<td>Morning tea</td>
<td></td>
</tr>
<tr>
<td>10:30</td>
<td>Paul Grundy</td>
<td>How might an outbreak of CLCuD occur in Australia and could it be contained?</td>
</tr>
<tr>
<td>12:30</td>
<td>Lunch</td>
<td></td>
</tr>
<tr>
<td>13:30</td>
<td>Susan Maas</td>
<td>CRDC</td>
</tr>
<tr>
<td>13:40</td>
<td>Ben Callaghan</td>
<td>HAL</td>
</tr>
<tr>
<td>13:50</td>
<td>John MacDonald</td>
<td>Nursery Industry</td>
</tr>
<tr>
<td>14:00</td>
<td>Rieks Vanklinken</td>
<td>CRCNPB</td>
</tr>
<tr>
<td>14:10</td>
<td>Formation of taskforce</td>
<td>How to progress research &amp; close gaps</td>
</tr>
<tr>
<td>15:30</td>
<td>Farewell Address</td>
<td></td>
</tr>
</tbody>
</table>

### Gap analyses of research & funding opportunities: Chair David Carey

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30</td>
<td>Paul Grundy</td>
<td>How might an outbreak of CLCuD occur in Australia and could it be contained?</td>
</tr>
<tr>
<td>12:30</td>
<td>Lunch</td>
<td></td>
</tr>
<tr>
<td>13:30</td>
<td>Susan Maas</td>
<td>CRDC</td>
</tr>
<tr>
<td>13:40</td>
<td>Ben Callaghan</td>
<td>HAL</td>
</tr>
<tr>
<td>13:50</td>
<td>John MacDonald</td>
<td>Nursery Industry</td>
</tr>
<tr>
<td>14:00</td>
<td>Rieks Vanklinken</td>
<td>CRCNPB</td>
</tr>
<tr>
<td>14:10</td>
<td>Formation of taskforce</td>
<td>How to progress research &amp; close gaps</td>
</tr>
<tr>
<td>15:30</td>
<td>Farewell Address</td>
<td></td>
</tr>
</tbody>
</table>
Evaluation of workshop

Thirty attendees were interviewed either at the workshop or a short time after and their views/comments sought on the highlights and value of the meeting.

All responses were positive and the major comments made were

- The presentations by both international and Australian speakers provided a comprehensive current view of the management of whitefly as pests and vectors of viruses across field crop and horticultural industries.
- The international perspective provided new information on biosecurity issues and problems occurring in Europe, the USA and Asia with the management of whitefly transmitted viruses.
- The diversity of attendees representing researchers, consultants, commercial companies and funding bodies across grain, fibre, vegetable and nursery industries allowed excellent transfer of knowledge and experiences and the opportunities to establish new contacts in areas outside delegates normal work areas.
- Most delegates found the gap analysis sessions valuable as these prompted good discussion and identified areas where work was required and issues involved in dealing with an incursion of a virus spread by a very mobile vector.
- An industry meeting at Bundaberg as part of the workshop was seen as a valuable means of presenting information to a wider industry audience, particularly with three experienced international workers present for the meeting.
- Attendees found the cost of registration good value and the Ecosciences Precinct venue convenient and suitable for the size of the meeting.

Key outcomes

This workshop achieved the following key outcomes:

- State of the art knowledge across industries of the biology, taxonomy and management of the silverleaf whitefly (SLW) and viruses transmitted by this insect.
- enhanced knowledge on potential actions required to contain/eradicate CLCuD if needed
- improved cross-industry awareness of CLCuD and other exotic pests
- improved cross-industry awareness of SLW management and insecticide usage
- a list of potential research areas required to manage SLW-transmitted viruses in grain, fibre and vegetable industries.
- opportunity to attempt area wide management of a SLW-transmitted virus in Australia
- enhanced network of virologists, entomologists and industry staff capable of responding to incursions of exotic SLW-transmitted viruses in grain, fibre and vegetable industries.
• a successful meeting for the vegetable industry in Bundaberg where 50 industry members discussed the current and potential problems in managing whitefly and other insect transmitted virus diseases in vegetables.

• Information from the workshop was disseminated through the abstract book provided to each delegate and also to other interested people who could not attend; through the industry meeting at Bundaberg and in discussions with funding bodies and industry groups in negotiating future project activities based on workshop recommendations.

Recommendations

• A proposal to develop and implement an area wide management strategy for whitefly and other key pests in vegetable crops be developed and discussed with industry by December 2012.

• Proposals to progress work on silverleaf whitefly and cotton leaf curl virus disease preparedness be developed and submitted to CRDC.

• Workshop delegates be kept informed of progress in these areas and formation of a taskforce to implement management strategies for whitefly be considered in the future on a needs basis.

Acknowledgements

We thank our sponsors, guest speakers, Sally Brown Conference Connections, Café Eco staff and the management team at the Ecosciences Precinct for their assistance.

Sincere thanks to our sponsors Horticulture Australia Ltd, Cotton Research and Development Corporation, Grains Research and Development Corporation, Queensland Government, Rijk Zwaan Australia and the CRC for Plant Biosecurity.

We thank Carrie Wright, DAFFQ for valuable secretarial assistance.
Appendix 1 - List of delegates

ABDEL-SALAM, Prof Aly
Professor Cairo University Faculty of Agriculture, Plant Pathology Department GIZA 12613 EGYPT Telephone (Work): +2 02 35719740 Fax: 2 0235717355 E-Mail: ammamoun@yahoo.com

ADKINS, Scot
Research Plant Pathologist (Virology) USDA ARS USHRL 2001 South Rock Road FORT PIERCE FL 34945 USA Telephone (Work): 1 (772)-462-5885 Fax: 1 772-462-5986 E-Mail: scott.adkins@ars.usda.gov

BAELDE, Mr Arie
Manager Rijk Zwaan Australia Pty Ltd
P.O. Box 284 DAYLESFORD VIC 3460 AUSTRALIA Telephone (Work): 03-5348 9003 Fax: 03-5348 5530 E-Mail: abaelde@rijkzwaan.com.au

BRAKE, Dr Vanessa
Plant Pathologist Dept Agriculture, Fisheries and Forestry 42-44 Qantas Drive EAGLE FARM QLD 4009 Telephone (Work): 07 32468705 E-Mail: vanessa.brake@aqis.gov.au

BRIDDON, Prof Rob
Foreign Faculty National Institute for Biotechnology and Genetic Engineering Jhang Road FAISALABAD 38000 PAKISTAN Telephone (Work): +92 41 2651475 EX 265147 Fax: +92 41 2651472 E-Mail: rob.briddon@gmail.com

BRIER, Mr Hugh
Senior Entomologist DAFF Qld, J. Bjelke-Petersen Research Station PO Box 23 Kingaroy Q 4610 KINGAROY QLD 4610 AUSTRALIA Telephone (Work): 07 41 600 740 Fax: 07 41 623 238 E-Mail: hugh.brier@daff.qld.gov.au

BURGER, Ms Courtney
Design Team Coordinator Ausveg 431 Burke Road GLEN IRIS VIC 3146 Telephone (Work): 03 9822 0388 E-Mail: courtney.burger@ausveg.com.au

CAMPBELL, Mr David
Technical Development Specialist Monsanto Level 12/600 St Kilda Road MELBOURNE VICTORIA 3004 E-Mail: david.nicholas.campbell@monsanto.com

CAREY, Mr David
Snr Horticulturalist DAFF Qld Eco Sciences Precinct Floor 3 C West GPO Box 46 BRISBANE QLD 4102 E-Mail: david.carey@daff.qld.gov.au

CLARK, Mrs Janine
Pest Management Officer Growcom 68 Anderson St FORTITUDE VALLEY QLD 4006 Telephone (Work): (07)3620 3878 Fax: (07)3620 3880 E-Mail: jclark@growcom.com.au

CLAYTON-GREENE, Dr Kevin
Biosecurity Consultant PO Box 396 PENGUIN TAS 7316 AUS Telephone (Work): 03 642 82505 E-Mail: kevin@harvestmoon.com.au

CONGREVE, Mr Mark
Senior Consultant ICAN Pty Ltd 14 Coral Cove Drive CORAL COVE QLD 4670 AUSTRALIA Telephone (Work): 0427 209 234 Fax: 07 4159 3696 E-Mail: mark@icanrural.com.au

CORNWELL, Mr Geoff
Field Development Manager DuPont (Aust) Ltd 36 Harvey St., Mt.Lofty TOOWOOMBA QLD 4350 Telephone (Work): 07 4638 0966 E-Mail: geoff.w.cornwell@aus.dupont.com

COUTTS, Ms Brenda
Research Officer Department of Agriculture and Food Western Australia 3 Baron-Hay Court SOUTH PERTH WA 6151 Telephone (Work): 08 9368 3266 E-Mail: brenda.coutts@agrafc.wa.gov.au

DENNIEN, Mrs Sandra
Experimentalist DAFF Gatton Research Facility LMB 7, MS 437, GATTON QLD 4343 Telephone (Work): 07 5466 2225 Fax: 07 5462 3223 E-Mail: Sandra.Dennien@daff.qld.gov.au

DUFF, Mr John
Senior Plant Protectionist Department of Agriculture, Fisheries and Forestry Gatton Research Facility LMB 7, MS 437 GATTON QLD 4343 Telephone (Work): 07 5466 2222 E-Mail: John.Duff@daff.qld.gov.au
ERBACHER, Mr Damien  
Director Dawson Ag Consulting Pty Ltd  
P.O. Box 429 THEODORE QLD 4719 Telephone (Work): 07 4993 2321 E-Mail: damien.e@dawsonag.com.au

FAINT, Mr Mitchell  
Senior Research and Development Specialist Bayer CropScience 7 Evergreen Drive BUNDABERG QLD 4670 Telephone (Work): 07 41553134 Fax: 07 41553134 E-Mail: mitchell.faint@bayer.com

FIRELL, Mrs Mary  
Experimentalist DAFF Gatton Research Station Locked Bag 7 MB 437 GATTON QLD 4343 Telephone (Work): (07) 54662263 Fax: (07) 54623223 E-Mail: Mary.Firell@daff.qld.gov.au

FOLDERS, Dr Jindra  
Rijk Zwaan Holland PO Box 40 2678 Zg DE LIER NETHERLANDS Telephone (Work): 31 (0)174 532 300 E-Mail: j.folders@rijkzwaan.nl

GAMBLEY, Dr Cherie  
Senior Plant Pathologist DAFF QLD Ecociences Precinct Dutton Park BRISBANE QLD 4102 Telephone (Work): 0429 872 410 E-Mail: Cherie.Gambley@daff.qld.gov.au

GEERING, Dr Andrew  
Senior Research Fellow The University of Queensland Ecociences Precinct 2C West, GPO Box 267 BRISBANE QLD 4001 Telephone (Work): 07 3255 4389 E-Mail: a.geering@uq.edu.au

GLOVER, Mr Phil  
Sumitomo Chemical PO Box 200 GUNNEDAH 2380 E-Mail: phil.glover@sumitomo-chem.com.au

GRAMS, Dr Raechelle  
Technical Officer (Entomology) Department of Agriculture, Forestry and Fisheries 203 Tor Street TOOWOOMBA QLD 4350 Telephone (Work): 07 4688 1534 E-Mail: raechelle.grams@daff.qld.gov.au

GRUNDY, Mr Paul  
Senior Scientist DAFF PO Box 102 TOOWOOMBA QLD 4350 Telephone (Work): 07 4688 1533 E-Mail: paul.grundy@daff.qld.gov.au

HALL, Mrs Zara  
Research Scientist DAFF 203 Tor St TOOWOOMBA QLD 4350 Telephone (Work): 07 46881436 E-Mail: zara.hall@daff.qld.gov.au

HORLOCK, Ms Christine  
Senior Plant Health Scientist Biosecurity Queensland, DAFF Qld BQCC PO Box 1241 OXLEY QLD 4075 Telephone (Work): 07 3310 2847 Fax: 07 3310 2864 E-Mail: christine.horlock@daff.qld.gov.au

JONES, Ms Lynne  
DAFF Biosecurity, Telephone (Work): (07) 4030 7835, Fax: (07) 4030 7845, E-Mail: lynne.jones@daff.gov.au

KELLY, Mr David  
Agronomist Cotton Consultants AustraliaPO Box 1121GOONDIWINDI QLD 4390 Telephone (Work): 0407 238 789Fax: 07 46715538E-Mail: david@macag.com.au

LEHANE, Mr John  
Senior Experimentalist DAFF 203 Tor St TOOWOOMBA QLD 4350 Telephone (Work): 07 4688 1265 E-Mail: john.lehane@daff.qld.gov.au

MAAS, Mrs Susan  
Senior Development & Delivery Specialist Cotton Research & Development Corporation PO Box 1722 EMERALD QLD 4720 Telephone (Work): 0409 499 691 Fax: 02 67924400 E-Mail: susan.maas@crdc.com.au

MCDONALD, Mr John  
Development Manager NGIQPO Box 345SALISBURY QLD 4107Telephone (Work): 07 3277 7900Fax: 07 3277 7109E-Mail: nido@ngiq.asn.au

MCGRATH, Mr Des  
Principal Horticulturist Department of Agriculture, Fisheries and Forestry Gatton Research Station LMB 7 MS 437 GATTON QLD 4343 Telephone (Work): 07 5466 2299 Fax: 07 5462 3223 E-Mail: Desmond.McGrath@daff.qld.gov.au
MORIONES, Dr Enrique
Head of Plant Virus Laboratory Consejo Superior De Investigaciones Cientificas (CSIC) Algarrobo-Costa S/n MALAGA 29750
SPAIN Fax: ( 34) 952552677 E-Mail: moriones@eelm.csic.es

O'GRADY, Mr Tim
Market Development Manager –QLD Bayer CropScience PO Box 261 WEST BURLEIGH QLD 4219 AUSTRALIA E-Mail: tim.ogrady@bayer.com

PARMENTER, Dr Kathy
Plant Pathologist (Virology) DAFF QLD Ecociences Precinct GPO Box 267 BRISBANE QLD 4001 Telephone (Work): 07 3255 4341 E-Mail: kathleen.parmenter@daff.qld.gov.au

PERSLEY, Mr Denis
Principal Plant Pathologist DAFF QLD Ecociences Precinct GPO Box 267 BRISBANE QLD 4001 Telephone (Work): 07 32554388 E-Mail: denis.persley@daff.qld.gov.au

ROACH, Ms Rebecca
Laboratory Technician Department of Agriculture, Fisheries & Forestry Ecociences Precinct GPO Box 267 BRISBANE QLD 4001 E-Mail: rebecca.roach@daff.qld.gov.au

RODONI, Dr Brendan
Senior Research Scientist Victorian DPI 621 Burwood Highway KNOXFIELD VIC 3156 Telephone (Work): 03 9210 9222 E-Mail: brendan.rodoni@dpi.vic.gov.au

SCHIAVON, Mr Maurice
Crop Specialist -Open Field Rijk Zwaan Australia PO Box 1662 BUNDABERG QLD 4670 Telephone (Work): 61 0413 273 885 E-Mail: m.schiavon@rijkzwaan.com.au

SENIOR, Dr Lara Entomologist DAFF QLD
Gatton Research Station LMB 7, MS 437 GATTON QLD 4343 Telephone (Work): 07 5466 2250 Fax: 07 5462 3223 E-Mail: lara.senior@daff.qld.gov.au

SEQUEIRA, Dr Richard
Principal Research Scientist Department of Agriculture, Fisheries and Forestry Locked Bag 6 EMERALD QLD 4720 Telephone (Work): 07 4983 7410 Fax: 07 4983 7459 E-Mail: richard.sequeira@daff.qld.gov.au

SHARMAN, Mr Murray
Senior Plant Pathologist Department of Agriculture, Fisheries and Forestry DAFF, Level 2C-West Ecociences Precinct, GPO Box 267 BRISBANE QLD 4001 Telephone (Work): 07 3255 4339 E-Mail: murray.sharman@daff.qld.gov.au

SLATTERY, Ms Jo
National Biosecurity Extension CoordinatorPlant Health Australia Level 11 Phipps CloseDEAKIN ACT 2600 Telephone (Work): 02 6215 7713Fax: 02 62604321E-Mail: jslattery@phau.com.au

SMITH, Dr Grant
Plant & Food Research Gerald Street LINCOLN 7608 NEW ZEALAND Telephone (Work): 64 3 325 9590 E-Mail: grant.smith@plantandfood.co.nz

SMITH, Dr Linda
Senior Plant Pathologist Qld DAFF Ecociences Precinct, Building 2C West, GPO Box 267 BRISBANE QLD 4001 AUSTRALIA Telephone (Work): 07 3255 4356 E-Mail: linda.smith@daff.qld.gov.au

STEELLE, Ms Vish
Laboratory Technician Department of Agriculture, Fisheries & Forestry Ecociences Precinct GPO Box 267 BRISBANE QLD 4001 Telephone (Work): 07 3255 4347 Fax: 07 3846 2387 E-Mail: visnja.steele@daff.qld.gov.au

SUBRAMANIAM, Dr Siva
Senior Entomologist DAFF Horticulture Research Station PO Box 538, Warwick Rd BOWEN QLD 4805 Telephone (Work): 07 4761400 Fax: 07 47852427 E-Mail: siva.subramaniam@deedi.qld.gov.au
TESORIERO, Dr Len
Industry Leader, Protected Cropping NSW DPI Private Bag 4008 NARELLAN NSW 2567 Telephone (Work): 02 4640 6217 Fax: 02 4640 6300 E-Mail: len.tesoriero@dpi.nsw.gov.au

THOMAS, Dr John
Principal Research Fellow The University of Queensland Ecosciences Precinct 2C West, GPO Box 267 BRISBANE QLD 4001 Telephone (Work): 07 3255 4393 E-Mail: j.thomas2@uq.edu.au

VAN BRUNSCHOT, Ms Sharon
PhD Candidate Cooperative Research Centre for National Plant Biosecurity Ecosciences Precinct 2C West, GPO Box 267 BRISBANE QLD 4001 Telephone (Work): 07 3255 4349 Fax: 07 3846 2387 E-Mail: sharon.vanbrunschot@deedi.qld.gov.au

WEBB, Mr Matthew
DAFF Ecosciences Precinct GPOBox 267 DUTTON PARK QLD 4001 E-mail: matthew.webb@daff.qld.gov.au

WILSON, Dr Lewis
Research Scientist CSIRO Locked Bag 59 NARRABRI NSW 2390 Telephone (Work): 02-6799 1550 Fax: 02-6793 1186 E-Mail: lewis.wilson@csiro.au

WINTERMANTEL, Dr William
Research Plant Pathologist USDA-ARS 1636 East Alisal Street SALINAS CA 93905 USA Telephone (Work): 1 (831) 755-2824 Fax: 1 (831) 755-2814 E-Mail: bill.wintermantel@ars.usda.gov

YOUNG, Ms Alison
Technical Liaison Officer SACOA Pty Ltd AUSTRALIA E-Mail: ayoung@sacoa.com.au
Appendix 2 – Abstracts

Simplifying the Complex. *Bemisia tabaci* a not so Complex Pest

By Paul De Barro

CSIRO Ecosystem Sciences, GPO Box 2583, Brisbane QLD 4001

The identity of *Bemisia tabaci* is a taxonomic question that goes back to 1889 and involves one of the world’s most important pests of agriculture, which despite its importance, has remained a taxonomic puzzle. Each year it destroys billions of dollars worth of crops in both developed and developing economies across Africa, Asia and the Americas. In developing economies it reduces the ability for communities to be self-sufficient in terms of food production and reduces their capacity to generate the cash essential to alleviating poverty. Yet despite its global importance, its taxonomy remains confused. Is it a single species with varying populations that exhibit different biological characteristics (i.e. biotypes) or a complex of morphologically similar species with different biological characteristics? This may seem an esoteric argument, but the answer has a significant bearing on the applicability and transferability of management practices between regions where the pest occurs, as these usually depend on insect biology, behaviour, natural enemies interactions and responses to agricultural chemicals; what works for certain populations may be ineffective for other populations. This presentation provides a summary of our understanding of the species complex and some the new learnings that are emerging as a result of the emerging new lens through which to view this pest.
Resistance Monitoring for Silverleaf Whitefly in Cotton

By Zara Hall¹, Raechelle Grams, Richard Lloyd and Paul Grundy

¹Department of Agriculture, Fisheries and Forestry, 203 Tor St, Toowoomba, Queensland, 4350.

zara.hall@daf.qld.gov.au

The Department of Agriculture, Fisheries and Forestry (DAFF), Field Crop Entomology Unit monitored the response of *Bemisia tabaci* B biotype, silverleaf whitefly (SLW) field populations to insecticides used in cotton from 2007 to 2012 in an ongoing Cotton Research and Development Corporation (CRDC) funded project (DAQ1104). The purpose of the research was to ascertain whether field populations of SLW were developing resistance to these insecticides.

Silverleaf whitefly field colonies were collected from cotton growing regions in Queensland and northern New South Wales (Emerald, Ayr, Theodore, Biloela, Moura, St George, Dalby, Brookstead, Mungindi, Moree and Narrabri). In addition, a limited number of samples were also collected from fruit and vegetable crops at Ayr, Bowen, Qld and Warburn in NSW. Colonies were maintained on cotton plants in the glasshouse and used for molecular biotyping and insecticide bioassays.

There are currently four insecticides registered for the control of SLW in cotton; pyriproxyfen, spirotetramat, bifenthrin and diafenthiuron. In addition, baseline data has been obtained for clothianidin, a registered insecticide for the control of other insects in cotton that has some activity against SLW. Full dose response bioassays were performed using a leaf-dip method on eggs (pyriproxyfen), nymphs (spirotetramat) and adult flies (bifenthrin, diafenthiuron and clothianidin). Silverleaf whiteflies were found to be completely susceptible to spirotetramat and diafenthiuron in cotton.

Pyriproxyfen is currently acknowledged as the cornerstone of effective management of high density infestations and while SLW remain susceptible to this insecticide over most of Australia, elevated resistance factors have been recorded in some regions. Studies conducted on a highly resistant, laboratory-created strain of SLW, showed that resistance decreased in the absence of selection pressure after 12 generations; however it did not completely revert to and subsequently remain at susceptible levels. From a management perspective, this indicates that the best management strategy is to prevent resistance developing by limiting selection pressure on any one product. For example, a maximum of one application of pyriproxyfen is recommended for use in cotton per cropping season.

Low but elevated levels of tolerance to bifenthrin have been recorded in many samples collected from cotton. This has been confirmed as resistance in one sample from St George through subsequent testing. Bifenthrin is generally not recommended as a product for SLW management except under circumstances whereby late season pest abundance may warrant its use just prior to defoliation. The earlier use of bifenthrin for SLW is not recommended as it has marginal efficacy and is highly disruptive to beneficial insects and often results in subsequent re-occurrence of SLW numbers within weeks of application.

The current best management strategy for resistance management in cotton as developed by the cotton Transgenic and Insecticide Management Strategy (TIMS) cotton industry committee is to limit selection pressure for any one mode of action group by minimising the use of high risk products such as pyriproxyfen to a
maximum use of one spray per season. Resistance has been recorded for pyriproxyfen in one sample from north Queensland however in all other cotton regions SLW remain susceptible to this product. Resistance also exists to bifenthrin however this product is generally not recommended for use in cotton for SLW management. Silverleaf whiteflies remain susceptible to diafenthiuron and spirotetramat making them useful insecticide options for control of SLW from a resistance management perspective.
Bemisia tabaci, biotype B (silverleaf whitefly): Ecological and pest management perspectives on an endemic pest in Central Queensland

By Richard Sequeira

Department of Agriculture Fisheries and Forestry, Queensland (DAFFQ), Locked Bag 6, Emerald, Q 4720

In the 2001-02 season, cotton growers in Central Queensland (CQ) witnessed a dramatic population explosion and regional outbreak of the silverleaf whitefly (SLW) from a very small base population at the start of the season. Being a relatively new arrival in Australia, the agro-ecology of SLW in regional production environments was largely unknown at the time of the outbreak. The SLW threat to the state and national cotton industries posed by the contamination of lint with whitefly honeydew and the high potential for loss of export markets prompted a rapid, multi-pronged response from the Australian RD&E agencies and the cotton industry. The response included in-crop management, local/regional validation and communication/extension perspectives.

From an in-crop management perspective, a whitefly sampling and population management strategy developed in Arizona (USA) cotton was imported and implemented in toto by the Australian cotton industry in 2002 as an emergency response to mitigate the immediate SLW threat to the regional and national industries. The SLW outbreak also provided the impetus for the development of a comprehensive SLW R&D program that ran from 2002 to 2006. This program detailed the population dynamics, host plant relationships and natural control of SLW in CQ. Spatial and temporal population growth profiles of SLW, the importance of natural mortality factors and relationships between major whitefly-hosting components of the cropping system were investigated. Parasitism of SLW by native aphelinid wasps was quantified to determine the potential for natural control of SLW populations. The field data were subsequently used to develop locally validated intervention and control guidelines that would provide stable, long-term management of SLW in Australian field crops.

From experiences of Bemisia management overseas, it was clear to the Australian cotton industry from the outset that an effective communication/extension and collaboration strategy was critical for stable and effective control of this pest. The CQ cotton industry developed and implemented a region-wide management strategy that was adopted by 100% of cotton growers and a significant proportion of the grain growing community in region. The main components of this strategy were:

- A voluntary ban on the use of broad-spectrum pyrethroid and organophosphate insecticide groups for the first post-outbreak cotton season followed by restricted use of these chemicals in the first half of the second and subsequent seasons
- A narrow planting window with strict beginning and end dates to minimise the occurrence of late planted crops
- A high level of internal communication and coordination within the cotton industry through Area Wide Management groups and grower meetings
- Collaboration between growers, consultants, research, extension, and the wider industry in activities such as the study tour to the USA
• Implementation of stop-gap protocols for in-crop management of SLW such as the standardised sampling procedure based on that developed by the University of Arizona and USDA

• Augmentation of natural enemy populations, helped by the reduction of early season broad-spectrum insecticide use

• The strategic use of insect growth regulator products and other selected products that prevented populations reaching outbreak situations and spreading to other crops, i.e., use of effective chemistry

• Coordinated spraying of crops wherever possible to avoid mosaic spray patterns

• Improved awareness and adoption of farm hygiene, including fallow weed management and post-crop destruction

• Establishment of a cross-industry SLW management and communications group that included representatives of the regional council, horticulture, grains and cotton industries, nurseries to keep town residents as well as agriculture related industries involved in the SLW management strategy

Since its inception and introduction ten years ago, the CQ SLW strategy has continued to provide effective control of SLW to the point where it is no longer considered a difficult to manage pest of cotton. Since about 2005, the spread of SLW to southern cotton and grain growing regions of Australia followed by the incidence of in-crop pest populations in a variety of crops, has resulted in the extension of the CQ SLW management strategy and experience to other regions. In this presentation I review the main elements of the SLW experience in the CQ (and by extension, the east coast) cotton and grain production systems.
Impact of silverleaf whitefly and challenges in implementing IPM in vegetable crops

By Siva Subramaniam1, Verni Sivasubramaniam1, and Robin Gunning 2

1Department of Agriculture, Fisheries and Forestry, Bowen, Queensland; 2NSW Department of Primary Industries, Tamworth Agricultural Institute, NSW

Silverleaf whitefly (SLW), Bemisia tabaci biotype B is a major horticultural pest that costs producers millions of dollars in lost production and control measures. SLW has become a major problem in tomato, eggplant, melons, zucchini, pumpkin, squash, cucumber, and sweet potato and occasionally in brassica and bean crops.

This polyphagous pest causes severe damage to vegetable crops through direct feeding, through honeydew contamination of product and by injecting a toxin into plants which causes physiological damage. The pest is also a vector of geminiviruses including tomato yellow leaf curl virus (TYLCV).

The pest’s adaptation to new crops, its migratory nature and ability to quickly develop resistance to insecticides are the major challenges for controlling the pest. The new generation insecticides such as pyriproxyfen, imidacloprid and pymetrozine have been widely used in vegetable crops to manage the pest. SLW has developed resistance to many insecticides worldwide and a high level of resistance has been detected in field populations in Queensland.

This HAL funded project integrated whitefly parasitoid releases with selective insecticides and best farm management practices. By using the parasitoid growers reduce spray applications and still deliver a better quality product. This provides growers with a sustainable and commercially viable IPM program and insecticide resistance management.

The project consisted of three steps for the whitefly IPM – parasitoid breeding, field releases and evaluations. Overall results from 4 years of evaluation clearly demonstrated that the parasitoid releases played a significant role in SLW control. In most of the crops parasitoids gave between 30 and 80 % control. Even in regularly sprayed crops such as tomato and eggplant average parasitism of 45% was achieved.

Three major Bowen-Burdekin growers have successfully adopted the whitefly IPM program developed by the project. These growers have 900 hectares of pumpkin, melons and eggplant under production with a farmgate value of $24 million. On these farms the project team released more than 400,000 parasitic wasps at an early stage of crop infestation. The wasps use the whiteflies to breed their own generation and ultimately reducing pest populations by 50 to 80 per cent.

Releasing parasitoids early in the crop’s growth appears to stabilise the whitefly population in the crop. Rates of parasitism increased within 2 to 4 weeks of the initial release. The data showed that integrating parasitoid releases with narrow-spectrum insecticides as part of an IPM program has maintained the whitefly population at its lowest levels.

Insecticide intervention is considered vital in some situations to control high infestations of whitefly nymphs, so as to reduce economic damage and spread to other crops. The new chemistry spirotetramat (Movento®) and pyriproxyfen (Admiral®) are effective ‘softer’ tools to integrate with parasitoids for SLW IPM in vegetables.
However, timing of application and effective crop monitoring are essential to maximise their effect.

Instil confidence in growers and obtaining their collaboration were key factors for the successful IPM implementation on-farm. The project team achieved this through intensive on-farm extension work which included regular farm visits for sampling the crops, advising on pesticide selections and early establishment of parasitoids in crops.

An industry survey conducted to evaluate the effectiveness of the project found that there was a perceived decrease in SLW damage in susceptible crops and an increased awareness and use of IPM strategies by growers and their consultants. Approximately 60% of growers indicated that they had made a recent change in the management of SLW.

Whitefly movement between farms is still an issue for all vegetable production regions. The mass migration of whiteflies from adjacent crops has hindered control measures adopted in the region. Movement of adults from older crops and crop residues is the primary source of infestation of young crops. Practical SLW dispersal control strategies are needed to address this issue.
Cotton leaf curl disease (CLCuD) is a serious disorder of cotton with characteristic symptoms, which include the formation of leaf-like enations on the undersides of leaves. The disease is caused by whitefly-transmitted geminiviruses (family Geminiviridae, genus Begomovirus) and specific, symptom modulating satellites (known as betasatellites). CLCuD occurs across Africa as well as in southern Asia. Over the past 25 years Pakistan and India have experienced two epidemics of the disease. The virus associated with the most recent epidemic overcame the conventional host-plant resistance that was introduced into commercial cotton varieties in the late 1990s. There has always been the fear that CLCuD could spread from the areas where it occurs at present to other cotton growing areas of the world where, although the disease is not present, the whitefly vector occurs and environmental conditions are suitable for its establishment. These fears have, unfortunately, been well founded, with CLCuD recently making its first appearance in China. The history of disease and recent advances made in understanding the molecular biology of the components of the disease complex and their interactions with host plants will be outlined.
The incidence of the whitefly-transmitted begomoviruses was examined in four different families (Cucurbitaceae, Fabaceae, Malvaceae, Solanaceae) of economic fibre, vegetable, and field crops and ten families of the ornamental crops (Amaranthaceae, Asteraceae, Euphorbaceae, Fabaceae, laminaceae, Malvaceae, Nyctaginaceae, Oleaceae, Rubiaceae, Solanaceae). Molecular analysis, including PCR, IC-PCR, RCA, and/or DNA sequencing, were used to detect the presence of begomoviruses in plant samples collected in Egypt over a two year period of time. The results indicated low diversity for the numbers of the detected viruses which included begomoviruses of the monopartite type (HLCrV, CLCV/OLCV and TYLCV) and a begomovirus of the newly introduced bipartite type, viz. SLCV; with a new isolate infecting watermelon and identified for the first time in Egypt. However, the biodiversity of these studied viruses was high since many of the known viruses were recorded in non-hosts especially in the tested ornamentals which probably represent a reservoir for these economic viruses. The incidence of satDNA associated with begomoviruses was very low and detected in only two of the tested samples. The presence of the begomovirus-associated satellites DNA βs revealed high biodiversity of these satellites in Egypt. Some but not all plant samples had detectable viral entities of DNA-A, DNA-B, and DNA β satellites comprising monopartite and bipartite viruses, all of which have been described in prior studies. This suggests that the diversity of begomoviruses in wild and cultivated plants in Egypt is relatively low, based on the plant species sampled in this study. Several new uncultivated (endemic) begomovirus hosts were identified and the prevalence of the recently introduced Squash leaf curl virus from the Western Hemisphere indicates that this invasive virus has established in several locations in Egypt. The addition of this exotic virus to the community suggests that it may play an important role in the further diversification of local viruses when mixtures occur in the same plant species either through drift, recombination, or re-assortment, as well as the possible acquisition of new beta satellites by SLCV that may modify viral virulence and fitness.
Diversity of Begomoviruses of Grain Legumes across Southern Asia

By Rob W. Briddon

Agricultural Biotechnology Division, National Institute for Biotechnology and Genetic Engineering, Jhang Road, Faisalabad, Pakistan

Grain legumes are an important source of dietary protein across southern Asia, but they suffer extensive losses due to several geminiviruses that are members of the genus Begomovirus, which are collectively known as legume yellow mosaic viruses (LYMVs), and the genus Mastrevirus. The mastreviruses are leafhopper-transmitted and mainly affect the “cool season” crops chickpea and lentil. Virtually all the other grain legumes are affected by LYMVs.

The LYMVs are genetically distinct from all other begomoviruses. The reason for this is unclear but it suggests that these viruses have a long evolutionary relationship with their hosts and have been “genetically isolated”, showing no evidence of recombination with begomoviruses that do not infect legumes. Recombination is a major mechanism for evolution of geminiviruses and the majority show evidence of recent recombination events. Across India grain legumes are affected by 4 species of LYMVs. In Pakistan, although there are multiple species of LYMVs, only one affects crops, the others only having been identified in weeds. Recent evidence suggests that the “genetic isolation” of legumes is under threat. Begomoviruses which do not normally infect legumes have been identified in grain legumes crops. Significantly these infections have included symptom modulating satellites which have proven so problematic in non-legume crops.
Ecology and Management of Whitefly-Transmitted Vegetable Viruses in the Southeastern United States

By Scott Adkins
USDA-ARS, U.S. Horticultural Research Laboratory, Fort Pierce, FL USA

Fresh market vegetables are economically important crops in Florida and other states in the southeastern U.S. A variety of viruses, most vectored by insects (including whiteflies, thrips and aphids), are established in the environment and pose relatively continuous challenges to production of vegetables and related agronomic crops. Two major vegetable crops (watermelon and tomato) and several viruses of each will be used as examples of the complex interplay between plant virus ecology and disease management strategies, especially in regions of the world with overlapping cropping seasons.

Aphid-transmitted potyviruses were the most economically important viral pathogens of watermelon and other cucurbit crops in the southeastern U.S. until the early 2000s. However, since 2005 three whitefly-transmitted viruses have been detected for the first time in Florida cucurbit crops and have become widespread in watermelon. Squash vein yellowing virus (SqVYV), identified in squash and watermelon in 2005 is perhaps the most devastating of these viruses. SqVYV causes a viral watermelon vine decline that occurs as crops approach harvest. Florida is most economically impacted by SqVYV although the virus has also been detected in Indiana, Georgia and South Carolina. Analysis of sequence diversity of SqVYV isolates collected at different times, from different locations and from different plant species suggests that SqVYV was introduced from elsewhere. In rapid succession, Cucurbit leaf crumple virus (CuLCrV) and Cucurbit yellow stunting disorder virus (CYSDV) were identified in Florida cucurbits in 2006 and 2007, respectively. Tomato yellow leaf curl virus (TYLCV) was first detected in south Florida in 1997. It has become widespread throughout the Florida peninsula where it remains the major viral pathogen of tomato. TYLCV has more recently been detected in other southeastern states including Georgia, South Carolina and Alabama. Tomato chlorosis virus (ToCV) was first identified in north Florida in 1996 and has subsequently spread throughout the state. However, symptoms of ToCV are generally obscured by those of TYLCV or the thrips-transmitted tospoviruses Tomato spotted wilt virus, an RNA reassortant of Groundnut ringspot virus and Tomato chlorotic spot virus, and Tomato chlorotic spot virus.

A thorough understanding of virus (and insect vector) biology and ecology is essential for successful management. In part, this is due to the need for sensitive and specific diagnostic test development for the virus to be managed, as proper pathogen identification is key for management. Biological and ecological knowledge of virus and vector is also critical for detection and management of reservoirs of both in the environment. Numerous surveys have been conducted in the region to identify alternate hosts for these whitefly-transmitted viruses. Cucurbit weeds including Balsam-apple (Momordica charantia), creeping cucumber (Melothria pendula) and smellmelon (Cucumis melo var. dudaim) provide reservoirs for SqVYV, CuLCrV and CYSDV. Green bean (Phaseolus vulgaris) also can provide a reservoir for CuLCrV, and pigweed (Amaranthus spp.) has been found infected with CYSDV. No wild plant species have been shown in Florida to serve as a reservoir for TYLCV. However,
research in Georgia has recently shown that TYLCV-resistant tomato plants can serve as reservoirs for both TYLCV and whiteflies.

Cultural, chemical and germplasm based management strategies include the use of reservoir reduction, UV reflective mulches, insecticides, sanitation, rouging and resistant crops. The effectiveness of insecticides and silver plastic mulch to manage whiteflies and mitigate SqVYV and TYLCV has been demonstrated. In addition, potential sources of SqVYV resistance have been identified in wild watermelon germplasm and a resistant line was recently released for use in watermelon breeding programs. Commercially available tomato cultivars with TYLCV resistance are available although use varies by growing area.

Ongoing surveys for these and other viruses and their insect vectors in Florida and beyond are benefiting from the development and current testing of a smartphone-based system to collect and upload GPS-labelled scouting data (virus, vector and production information) to a central server where it can be processed and analyzed. When fully implemented, this all-inclusive smartphone application, currently known as AgScouter, will deliver real-time reports and management recommendations to growers and/or their scouts making possible “area-wide” management of diseases and pests, including whitefly-transmitted viruses.
Emergence and Management of Whitefly-Transmitted Viruses Affecting Melon Production in Southern California.

By William M. Wintemantel and James D. McCreight
USDA-ARS, Salinas, CA, USA

Melon production in the southwestern United States has been impacted by several whitefly-transmitted viruses over the past few decades. This has led to increased research for both vector management and identification and control of whitefly-transmitted viruses. During the 1980s Lettuce infectious yellow virus (LIYV; family Closteroviridae; genus Crinivirus) was a significant threat to production of melon as well as lettuce, sugarbeet, and other crops. Populations of Bemisia tabaci biotype A increased over the summer months annually, and resulted in early infection and severe losses for fall melon production in California and Arizona. During the early 1990s, a sudden shift in the whitefly population from biotype A to biotype B virtually eliminated LIYV from the region due to the extremely poor rate of transmission of LIYV by B. tabaci biotype B. Consequently, fall melon production was renewed in the region over the next decade with effective usage on new insecticides to control the high populations of B. tabaci biotype B. The emergence of Cucurbit yellow stunting disorder virus (CYSDV) in 2006, resulted in universal infection of the entire melon crop in the region, reducing sugar content in fruit and rendering melons unmarketable, again drastically reducing Fall melon production from the American Southwest as well as northern Mexico. CYSDV incidence was low in Spring melons and limited to a small number of fields. The severity and speed with which CYSDV affected melon production led to an intensive effort to characterize the epidemiology of this virus in its new range and aggressive efforts toward control.

Early studies indicated the host range of CYSDV was limited to members of the Cucurbitaceae, but survival through a severe freeze that eliminated virtually all cucurbit hosts suggested the possibility of alternative hosts for CYSDV. Weed and crop hosts were collected from throughout California’s Imperial Valley over a period of 26 months, and were tested for the presence of CYSDV by RT-PCR using CYSDV HSP70h- and coat protein gene-specific primers to identify potential reservoir hosts and elucidate virus epidemiology. Many non-cucurbits collected from infected melon fields and nearby areas were asymptomatic and virus-free; however, CYSDV was detected in plants from eight different families. Transmission tests demonstrated that lettuce, snap bean, alkali mallow, Wright’s ground cherry and buffalo gourd (Cucurbita foetidissima) are potential reservoir hosts from which the virus could be transmitted to melon. These results greatly expanded the previously known host range of CYSDV. Several reservoir hosts are being evaluated for virus titre and efficiency of virus transmission to cucurbits in efforts to identify the more significant alternate hosts during periods in which cucurbits are not present in the field.

Melon PI 313970 exhibited high-level resistance to CYSDV in replicated field tests in Yuma, Arizona and Imperial Valley, California. Mean plant condition ratings of PI 313970 were significantly ($P_{0.05}$) better than those of the susceptible control, ‘Top Mark.’ Data from a cross with the CYSDV-resistant melon TGR-1551 indicated potential for significantly higher resistance than that exhibited by either resistance source alone. Although resistance to CYSDV may be increased with these sources combined, they must be used in combination with an active insecticide treatment program due to excessively high whitefly feeding pressure. Breeding to transfer resistance form PI 313970 and TGR-1551 to horticulturally acceptable germplasm,
and research to optimize vector and alternate host management are anticipated to eventually restore the potential for fall melon production within the region.
Occurrence of *Cucurbit yellow stunting disorder virus* and *Cucumber vein yellowing virus* in Cucurbits in Egypt

By Aly, M. Abdel-Salam

Plant Pathology Department, Faculty of Agriculture, Cairo University, Giza 12613, Egypt

Corresponding author: Fax: +2 0235717355; E-mail: ammamoun@yahoo.com

Both *Cucurbit yellow stunting disorder virus* (CYSDV) and *Cucumber vein yellowing virus* (CVYV) cause severe yellowing on cucurbit crops in Egypt. Both viruses infect cucumber (*Cucumis sativus*), melon (*Cucumis melo*), watermelon (*Citrullus lanatus*), and zucchini squash (*Cucurbita pepo*). CYSDV and CVYV are transmitted by the whitefly *Bemisia tabaci* insect. CYSDV develops interveinal chlorosis and yellowing, leaf brittleness and rolling on cucurbits; beginning from older leaves and spreading upward. CVYV provokes vein clearing followed by leaf chlorosis, chlorotic mosaic, and cracking on fruits. CYSDV and CVYV were partially purified using an electrophoresis technique. Produced antisera for both viruses were used in dot blotting immunobinding assay (DBIA) for detection of virus infection in different cucurbits. The present study reports the incidence of CVYV in Egypt for the first time.
Viruses Affecting Tomatoes Grown in Protected Cropping Systems in Spain

By Enrique Moriones

Instituto de Hortofruticultura Subtropical y Mediterránea “La Mayora”, Consejo Superior de Investigaciones Científicas (IHSM-UMA-CSIC), Estación Experimental “La Mayora”, E-29750 Algarrobo-Costa, Málaga, Spain

Tomato (Solanum lycopersicum L.) production constitutes a major agricultural industry worldwide with about 26% of world’s production done in the Mediterranean basin. In this latter geographical region, Spain is a major tomato producer. Viral diseases highly affect tomato production in the intensive protected cropping systems in Spain. During the last decades several viruses have emerged threatening tomato crops in Spain. Among them, are notorious viruses transmitted by the whitefly (Hemiptera: Aleyrodidae) Bemisia tabaci such as geminiviruses (genus Begomovirus, family Geminiviridae) causing the tomato yellow leaf curl disease, criniviruses (genus Crinivirus, family Closteroviridae) causing yellowings in tomato, or the most recently emerged, the torradovirus (genus Torradovirus) Tomato torrado virus. Although currently controlled based on genetic resistance in the host plant, a special mention should also be done of the thrips (family Thysanoptera)-transmitted virus Tomato spotted wilt virus (genus Tospovirus, family Bunyaviridae) that has constituted a major limiting factor for tomato production during late 1980s. Finally, although insect-transmitted viruses are the most damaging viruses in tomatoes grown in protected cropping systems, also the seed and mechanically-transmitted potexvirus (genus Potexvirus, family Flexiviridae) Pepino mosaic virus is causing serious damage to tomato production. Biological, epidemiological and control aspects will be reviewed for these viruses based on our experience about the epidemics caused in Spain.
Detection of a Begomovirus from Sweet Potato Plants in Egypt

By Aly. M. Abdel-Salam

Plant Pathology Department, Faculty of Agriculture, Cairo University, Giza 12613, Egypt

Corresponding author: Fax: +2 0235717355; E-mail: ammamoun@yahoo.com

Leaf curl symptoms associated with heavy infestations with the sweet potato whitefly Bemisia tabaci have often been observed in sweet potato plantations in several locations in Egypt. Symptomatic leaves with upward curling were PCR negative when tested with degenerate primers for badnaviruses. Similarly, immunocapture-PCR trials using a cocktail of ten-begomovirus antisera and Acore degenerate primers for the core coat protein of begomoviruses failed to detect virus presence. Only when using touch down PCR and the begomovirus degenerate primers SPG1 (sense) 5′-CCCCKGTGCGWRAATCCAT-3′ and SPG2 (antisense) 5′-ATCCVAAAYWTYCGGAGCTAA-3′, a 912 bp amplicon was detected indicating the presence of a begomovirus in the symptomatic sweet potato leaves.
Status and Future Management Strategies of Cotton Leaf Curl Virus Disease in India

By D Monga1, P K Chakrabarty, K R Kranthi2 and N Gopalakrishnan3

1Head, Central Institute for Cotton Research (CICR), Regional Station, Sirsa; 2Head, Division of Crop Improvement, Central Institute for Cotton Research, Nagpur and Director, Central Institute for Cotton Research, Nagpur; 3Assistant, Director General(Commercial Crop), Indian Council of Agricultural Research, Krishi Bhawan, New Delhi

Cotton leaf curl virus disease (CLCuD), caused by a single stranded circular Gemini virus consisting of DNA- A and two satellites ie DNA-1 and DNA beta and transmitted by white fly (Bemisia tabaci) is an important problem in north Indian states of Haryana, Punjab and Rajasthan where around fourteen lakh hectares of cotton is cultivated. CLCuD was first noticed in Nigeria on Gossypium peruvianum and G. vitifolia whereas the disease was first observed in our neighboring country Pakistan in 1967. In India, the disease after its first appearance on G. hirsutum in patches around Sriganganagar district of Rajasthan in 1993 spread to the entire northern cotton growing region in a short span of 4-5 years. The initiation of disease is characterized by small vein thickening (SVT) type symptoms on young upper leaves of plants. Upward leaf curling followed by formation of cup shaped leaf laminar out growth of veinal tissue on the abaxial side of the leaves are other important symptoms. In severe cases reduction of internodal length leading to stunting and reduced flowering/fruiting is also noted. Considerable potential for reduction in seed cotton yield in India in the states of Rajasthan (32.9-50.3%), Punjab (10.5-92.2%) and Haryana (39.4-81.4%) due to this disease has been reported. The effective management of this important disease is possible by development of resistant varieties, suppression of whitefly and eradication of weed hosts carrying virus inoculum. Studies on the identification of resistant sources, development of resistant varieties and hybrids, molecular diagnostic tools, crop loss estimation and epidemiology including weeds hosts carrying the virus have been extensively carried out during the past two decades. Recent studies have revealed breakdown of resistance due to development of new recombinants. New management strategies include marker assisted selection, development of transgenics using RNA interference mediated approach and use of other innovative approaches for containing whitefly and virus in the field.
Tomato yellow leaf curl virus in Australia: Distribution & Resistance Breeding

By John Thomas¹, Sharon van Bronschoot²,³, Denis Persley⁴, Des McGrath⁴, Andrew Geering¹, Cherie Gambley⁴, Rebecca Roach⁴, Paul Campbell⁴

¹The University of Queensland, Queensland Alliance for Agriculture and Food Innovation, Ecosciences Precinct, Dutton Park Queensland 4102; ² Cooperative Research Centre for National Plant Biosecurity, LPO Box 5012, Bruce, ACT 2617; ³School of Biological Sciences, The University of Queensland, St Lucia, Qld 4067; ⁴Department of Agriculture, Fisheries and Forestry, Ecosciences Precinct, Dutton Park Queensland 4102

Tomato yellow leaf curl virus (TYLCV) has only recently appeared in Australia. The first positive detection was from cherry tomatoes in market gardens around the southern perimeter of Brisbane in March 2006. Anecdotal evidence suggests that the virus may have been present at least four months prior to detection. Initial diagnoses were based on begomovirus-specific ELISA, with confirmation by TYLCV-specific PCR and sequencing. Subsequent surveying in 2006 revealed that the virus was widespread and common in the periurban areas to the south of Brisbane, with incidences frequently near 100%. It was also present in the commercial production areas of the Lockyer and Fassifern Valleys and Bundaberg, but generally at a low incidence. By 2009, the virus was common in Bundaberg, with incidences frequently over 50%. It was recorded in Murwillumbah in 2010 and in Bowen and Mareeba in 2011.

All isolates of TYLCV from Australia are closely related, with at least 98.6% total genome identity, and at least 98% identity to TYLCV-IL isolates from overseas. Interestingly, restriction digests and subsequent sequencing showed that isolates from Brisbane/Murwillumbah, Bundaberg, Bowen and Mareeba each formed phylogenetically distinct groups consistent with their geographic location. No DNA-B components, or α- or β-satellites were detected in any isolates, but one isolate from Brisbane contained three distinct defective DNAs, about half genome size, and comprising partial, rearranged fragments of the native DNA-A molecule. This isolate was whitefly transmitted and showed typical disease symptoms. A Brisbane isolate of TYLCV was transmitted by the B-biotype (Middle-east Asia Minor 1 species) of Bemisia tabaci to Phaseolus vulgaris and Datura stramonium in which severe leafcurling symptoms developed, and to Capsicum annuum which did not develop symptoms. Field hosts of TYLCV in the Bowen area are Amaranthus sp. and Portulaca sp.

Resistance genes Ty-1 and Ty-5 are both effective against Australian isolates of TYLCV, and these isolates react as expected against the differential tomato lines STY-1 to STY-7 developed by Lapidot et al (2006) for the evaluation of resistance to TYLCV. Tomato yellow leaf curl disease has become a major limiting factor to tomato production in the major production areas of Bowen and Bundaberg, and as a result, many resistant tomato cultivars have been introduced into these areas. Unfortunately, there have been yield and quality penalties, as these cultivars are often not well adapted to local growing conditions. DAFF Queensland, has a tomato breeding program where Ty-1 has been introgressed into breeding lines also containing powdery mildew resistance, and these near inbred lines are now suitable as parents for producing TYLCV-resistant hybrids.
Reference:
Whitefly Transmitted Viruses Affecting Vegetables Growing Under Protected Cropping Systems in Australia

By Denis Persley¹, Cherie Gambley¹, Rebecca Roach¹, Visnja Steele¹, Len Tesoriero², John Thomas³, Brendan Rodoni⁴

¹Department of Agriculture, Fisheries and Forestry, Ecosciences Precinct, Dutton Park Queensland 4102; ²NSW Department of Primary Industries, Menangle NSW 2568; ³The University of Queensland, Queensland Alliance for Agriculture and Food Innovation, Ecosciences Precinct Dutton Park Qld 4102; ⁴Department of Primary Industries, Victoria

Production of vegetable crops in protected cropping systems is an important and expanding segment of the Australian vegetable industry. The major crops within this system are tomato, lettuce, cucumber and herbs.

The two whitefly transmitted viruses of concern in protected cropping in Australia are Beet pseudoyellows virus (BPYV) and Tomato torrado virus (ToTV)

The crinivirus BPYV was first found on Taraxacum officinale (dandelion) in Tasmania in 1981. The virus attracted little further attention until it was found to be the cause of cucumber yellows disease in greenhouse grown crops in 2008. This disease has most likely affected greenhouse grown cucumber crops in southern Australia for some years with the extent of the problem only becoming apparent in recent years, as symptoms can be difficult to distinguish from those due to nutritional and environment disorders.

The virus has been found in greenhouse cucumber crops on the North Adelaide Plain (NAP), Sydney Basin and the north coast of New South Wales. The vector species Trialeurodes vaporariorum is favoured by greenhouse environments and disease incidence frequently exceeds 50% as crops mature. Several weed hosts have been identified including Chenopodium murale, Malva parviflora and Lactuca serriola.

The agent responsible for tomato torrado disease in Spain was identified in 2007 as a picornavirus-like bipartite RNA virus and named Tomato torrado virus. This virus is now the type species of the new genus Torradovirus, family Secoviridae. Other members of the genus are Tomato marchitez virus, Tomato chocolate spot virus and Tomato chocolate virus, which have been reported from Mexico and Guatemala.

These viral species all cause leaf epinasty, necrotic spots on the basal parts of young leaves, terminal necrosis and necrotic lesions and cracking on fruit.

Greenhouse grown tomato crops on the North Adelaide Plain displayed similar symptoms to those mentioned above and ToTV was confirmed in 2008 by RT-PCR followed by cloning and sequencing of PCR products. The virus was subsequently identified from an archived sample from 2005 from NAP and in 2010 from Lara, Victoria.

Although ToTV can be transmitted by both Bemisia tabaci and Trialeurodes vaporariorum, transmission in Australia is via the latter species as B. tabaci is not established in either NAP or Lara, Victoria, the only two areas where ToTV has been detected in Australia.

ToTV is well established in greenhouse tomato crops on the NAP with tomato hybrids displaying a range of symptoms from very severe necrotic symptoms to high resistance to infection. Symptomless natural infection has been found in eggplant and
capsicum. Several surveys have failed to detect ToTV in a range of common weed species.
Insect-transmitted viruses cause significant losses annually for tomato production in western North America (California and western Mexico). Considerable variability exists among viruses impacting production throughout the region. This is influenced by variable climatic conditions which affect vector populations, as well as cropping pattern, and the prevalence of alternate hosts. The Central Valley of California is affected primarily by thrips, aphid, and leafhopper-transmitted viruses. Historically agriculture in this region where most US processing tomatoes are produced has been impacted by Beet curly top virus and related curtovirus species, transmitted by the beet leafhopper (Circulifer tennellus). These viruses continue to plague processing tomato production in the region. Within the past decade incidence of thrips-transmitted Tomato spotted wilt virus has greatly increased, and now rivals curtovirus infections as a significant production threat in the region. Coastal tomato production in California is limited, but is primarily affected by the crinivirus, Tomato infectious chlorosis virus (TICV) transmitted by the greenhouse whitefly (Trialeurodes vaporariorum), along with periodic outbreaks of aphid-transmitted viruses and curly top. TICV and aphid-transmitted viruses, also impact greenhouse production in California. Tomato yellow leaf curl virus (TYLCV) was introduced in 2007 into California’s Imperial Valley, through movement of infected plant material, and in spite of aggressive efforts to eradicate it, the virus established in native plant species. TYLCV is readily transmitted by high populations of Bemisia tabaci biotype B that occur from mid-summer through fall. Interestingly, TYLCV has had little impact on production in California, since tomato is not a significant crop in the Imperial Valley production region, and B. tabaci is rarely found in the Central Valley or in coastal production regions, reducing the potential for vector transmission. Tomato production in Mexico is more significantly affected by whitefly-transmitted viruses than California. TYLCV and other tomato-infecting begomoviruses can be found, as well as the criniviruses, TICV and Tomato chlorosis virus (ToCV). Recently, several new species of the emerging genus, Torradovirus, have been identified infecting tomato in Mexico. The abundance of whitefly-transmitted viruses in this region, along with numerous other viruses common to tomato production, necessitates intensive virus identification and management efforts.
Control of Whitefly-transmitted Viruses Affecting Tomatoes Grown in Protected Cropping Systems in Spain

By Enrique Moriones

Instituto de Hortofruticultura Subtropical y Mediterránea “La Mayora”, Consejo Superior de Investigaciones Científicas (IHSM-UMA-CSIC), Estación Experimental “La Mayora”, E-29750 Algarrobo-Costa, Málaga, Spain

Tomato (Solanum lycopersicum L.) production in protected cropping systems in Spain is severely affected by viral diseases transmitted by the whitefly (Hemiptera: Aleyrodidae) Bemisia tabaci such as geminiviruses (genus Begomovirus, family Geminiviridae) causing the tomato yellow leaf curl disease (TYLCD), criniviruses (genus Crinivirus, family Closteroviridae) causing yellowing in tomato, or the most recently emerged, the torradovirus (genus Torradovirus, family Secoviridae) Tomato torrado virus. Control of these viruses is mainly based on intense insecticide applications to reduce insect vector populations, although this is only partially effective which could result into deleterious effects on the environment. Also, the development of insecticide-resistant vector populations occurs. Therefore, the best virus control approach in this case would be the development of an integrated management approach. Control strategies based on crop management or the use of genetic resistance in the host could be combined for a more durable and effective virus control. Control of the TYLCD will be used as model system to present results of strategies that could be used to reduce yield losses in tomato protected crops. Measures based on the use of UV-absorbing plastic sheets, elicitation of resistance response in plants based on products that induce systemic acquired resistance or the use of genetic resistance to the virus and/or to the vector have been investigated and will be discussed.
The management of begomovirus diseases, as with all arthropod borne pathogens, has long depended upon the use of insecticides to control the vector. However, as the negative environmental and health effects of insecticide use has become evident, and many active ingredients have been withdrawn from use, the control of these pathogens has become problematic. This has been aggravated by the propensity of the vector of begomoviruses, *Bemisia tabaci*, to become resistant to insecticides. Another mainstay of begomovirus control has been the production of resistant varieties by conventional breeding. Although there have been some successes by this approach, for many begomoviruses few sources of resistance genes are available in germplasm collections, leading breeders/researchers to seek resistance from more unusual sources, including the use of transgenesis. The transgenic approach has been shown, both in the laboratory and in limited field trials, to have the potential for success, although no transgenic begomovirus-resistant have yet come into commercial use. However, it has become clear that, whether developed by conventional or non-conventional means, the durability of begomovirus resistance will depend upon the diversity of viruses in the environment in which they are grown. In Pakistan, where virus diversity is high, conventional resistance to cotton leaf curl disease introgressed into local cotton varieties in the 1990s, was broken within 5 years of its introduction.
Silverleaf whitefly’s (SLW’s) arrival in Australia in the mid 1990’s posed a significant threat to SLW preferred grain legumes, particularly soybeans. Extremely high populations were observed in many regions, to the extent that predictions were made that SLW would lead to the demise of soybeans as a viable crop in much of Queensland. The sense of crisis was heightened because no pesticides were registered for SLW in grains and the most effective potential pesticide options were too expensive for crops of markedly lower crop value than cotton. By default therefore, the strategy for managing SLW in grain legumes has been (1) to maximize the effectiveness of beneficials targeting SLW, and (2) to develop complementary IPM strategies for pests other than SLW. Key strategy components have been (a) planting of ‘poor SLW host’ grain legume crops (e.g. mungbeans) in high risk regions (particularly CQ), (b) the ‘go soft early’ strategy of using only caterpillar biopesticides prior to flowering, particularly in soybeans, (c) the use of selective options wherever possible in flowering/podding crops (e.g. indoxacarb for helicoverpa), and (d) economic threshold research to identify pest/crop scenarios where spraying can be avoided (e.g. for mirid populations ≤ 5/m² in soybeans) or delayed (e.g. no podsucking bug sprays until podfill in all summer legumes). The aims of strategies (b), (c) and (d) are to conserve beneficial insects in general, but more specifically those attacking SLW, particularly the very effective exotic wasp parasite *Eretmocerus hayati*. The introduction of *E. hayati* (by CSIRO) constitutes strategy (e); classical biological control. Overall the strategies above have proved effective with <5% of soybean crops on average in most regions suffering significant SLW damage, much lower activity in peanuts, and no reports of SLW damage in mungbeans. It should be noted that the above strategies aim to contain SLW populations at ‘below economic levels’ with regard to yield loss. They would most likely be ineffective in preventing the spread of SLW-vectored diseases such as *Mungbean yellow mosaic virus* (MYMV). Nor would reliance on SLW pesticides be a viable option (assuming they could be registered in grain legumes). The failure of this approach has been demonstrated for many other insect-vectored diseases, e.g. for thrips-vectored *Tomato spotted wilt virus* (TSWV) in peanuts. In such scenarios, the most effective strategy has often been the development of resistant cultivars, an approach with the most potential for combating MYMV in mungbeans.

By Lewis Wilson and Simone Heimoana

CSIRO Plant Industry and Cotton Catchment Communities CRC, Locked Bag 59, Narrabri, NSW, 2390;

Silverleaf whitefly (Bemisia tabaci B-biotype, SLW) entered Australia in the mid 1990’s and has progressively achieved pest status in all major cotton production regions. Local management systems have been developed based on research in Arizona and in the Central Queensland region (see abstract of Sequeira). As this pest has spread to the larger central cotton regions new questions have arisen including (i) how does management of other pests affect SLW management and (ii) what is the fate of honeydew on contaminated bolls. High adoption of Bt-cotton containing the Cry1Ac and Cry2Ab proteins has allowed dramatic reductions in pesticide use (from 8-12 down to <1) against Helicoverpa spp., the primary pest. Ironically, reduced spraying has allowed the green mirid (Creontiades dilutus) and green vegetable bug (Nezara viridula) to survive and they now require control (1-3 sprays). Control of these pests using broad-spectrum insecticides increases the risk of encouraging whitefly outbreaks. In addition, cotton pest management practitioners have noted that SLW were often more abundant in transgenic crops than conventional crops. Further, in small plot experiments okra leaf shaped genotypes appear to harbour fewer SLW. We compared SLW population development between Bt and non-Bt varieties, between okra leaf and normal leaf shaped varieties, and between sprayed (for mirids) and unsprayed systems. We found higher abundance of SLW on the non-transgenic cotton. Differences in SLW abundance between Bt and non-Bt in commercial crops are likely due to differences in spray regimes. Secondly, the okra leaf variety had significantly fewer SLW than the normal leaf cultivar, confirming valuable plant resistance. Finally sprayed cotton had higher abundance of SLW, indicating the detrimental effect on beneficial species. The results suggest a combination of okra leaf shape, transgenic cotton to reduce the need to spray, and use of selective mirid control will be options to help manage SLW. The fate of honeydew on contaminated bolls has been studied using both naturally deposited as well as synthetic honeydew applied to cotton bolls which are then exposed to field conditions. Limited data available so far suggests that rainfall can dramatically reduce contamination levels on bolls. Questions being addressed include distribution of honeydew within the canopy, effects of sunlight and micro-organisms, especially sooty moulds, on sugar decline and also effects of these processes on fibre quality. The research aims to provide growers with rational guidelines to assess the level of contamination of bolls, options to deal with problem situations and method to decide when it is safe to harvest.
New Technologies for the Multiplexed Detection of Begomoviruses and their Whitefly Vectors

By Sharon van Brunschot¹,², René van der Vlugt³, Jan Bergervoet³, Marjanne de Weerdt³, Cherie Gambley⁴, Daniel Pagendam⁵, Paul De Barro⁶, Raechelle Grams⁴, John Thomas⁷, Juliane Henderson⁷, André Drenth⁷, and Andrew Geering⁷

¹CRC for National Plant Biosecurity, ²School of Agriculture and Food Sciences, The University of Queensland, ³Plant Research International, Wageningen University and Research Centre. The Netherlands, ⁴Queensland Department of Agriculture, Fisheries and Forestry, ⁵CSIRO Mathematics, Informatics and Statistics, ⁶CSIRO Ecosystem Sciences, ⁷Queensland Alliance for Agriculture and Food Innovation, The University of Queensland.

Whitefly-transmitted begomoviruses (family Geminiviridae) cause economically important diseases in a wide range of food and fibre crops. The global emergence and spread of begomovirus diseases is closely linked with the globalization of trade, the ability of begomoviruses to rapidly evolve and associate with auxiliary symptom-enhancing subviral components (e.g. satellite molecules), and the parallel dispersal and establishment of members of the cognate vector Bemisia tabaci species complex.

In 2006, Tomato yellow leaf curl virus-Israel (TYLCV-IL) was first discovered in open field tomato production in south-east Queensland, Australia. TYLCV-IL has since become a significant constraint to tomato production in all of the major tomato growing regions of Queensland. The establishment of TYLCV-IL in Australia was aided by the presence of B. tabaci Middle East Asia Minor 1 (MEAM1, commonly referred to as biotype B), which was first identified in Australia in the early 1990s. The introductions of both B. tabaci MEAM1 and TYLCV-IL highlight the need for improved detection and surveillance measures to limit the expansion of TYLCV-IL, and reduce the risk of future introductions of new species of begomoviruses and B. tabaci. Of particular quarantine concern in Australia is the exotic B. tabaci Mediterranean (MED, commonly referred to as biotype Q), a globally invasive species that is resistant to a wide range of insecticides and causes severe economic losses in a range of horticultural crops. Here we describe two new approaches for the simultaneous identification of the viruses and vectors responsible for tomato yellow leaf curl disease (TYLCD) epidemics.

Firstly, we describe the development of a panel of multiplexed quantitative real-time PCR (qPCR) assays for the sensitive and reliable detection of TYLCV-IL, Tomato leaf curl virus (ToLCV), B. tabaci MEAM1 and B. tabaci MED from either plant or whitefly samples. Two internal control assays were included in the assay panel for the co-amplification of either solanaceous plant DNA or B. tabaci DNA, enabling the monitoring of the entire diagnostic process from extraction to qPCR result, to exclude false negative results. Validated methods for the routine testing of field-collected whiteflies, including methods for processing B. tabaci captured on yellow sticky traps and for bulking of multiple B. tabaci individuals prior to DNA extraction, will be presented.

Secondly, we report on the first application (proof of concept research) of Luminex bead-based suspension array technology for the detection of plant viruses and their vectors. Luminex MagPlex-TAG bead technology is a recently developed platform for the simultaneous detection of multiple targets, which is demonstrating rapid adoption for the clinical diagnosis of infectious diseases (Dunbar, 2006). Benefits of
the suspension array technology include large multiplexing capability (up to 100 separate targets), rapid data acquisition and flexibility and ease of modification of the array panel. For nucleic acid based detection, the PCR-Luminex MagPlex-TAG system monitors the specific hybridization events that occur between sequence-tagged (MagPlex-TAG-labeled) PCR products with their complementary anti-MagPlex-TAG oligonucleotide probes coupled to spectrally distinct bead sets using a flow cytometer. We describe a 7-plex PCR-Luminex array for the hierarchical detection of begomoviruses (including TYLCV-IL) and cryptic species of B. tabaci. The hierarchical assay design incorporates both “universal” genus/molecule specific assays in addition to targeted species-specific assays. The PCR-Luminex array was extensively validated and demonstrated excellent specificity, sensitivity (equivalent to qPCR) and reproducibility over ten independent tests.

Both the multiplexed qPCR panel of assays and the novel PCR-Luminex multiplexed bead arrays provide powerful and flexible new approaches for the rapid, sensitive and reliable simultaneous identification of viruses and vectors responsible for TYLCD epidemics. These methods will likely facilitate improved biosecurity and quarantine prevention and management programs, both in Australia and worldwide. In addition, the virus-specific qPCR assays are well suited for use in plant virus resistance breeding programs.

Contingency Planning for Whitefly transmitted Viruses in the Nursery Industry

By Jo Slattery

Plant Health Australia

Australia’s geographic isolation and active quarantine systems have meant that it is relatively free of many pests that cause significant problems for plant production and amenity use overseas. Maintaining Australia’s freedom from these exotic pests is a real trade benefit for Australia in terms of securing market access domestically and internationally. Maintenance of our plant health status is vital for retaining existing trade opportunities, negotiating access to new overseas markets and ensuring the future profitability and sustainability of our plant industries.

Plant Health Australia (PHA) is the national coordinator of the government-industry partnership for plant biosecurity in Australia, with the nursery and garden industry represented by Nursery and Garden Industry Australia Ltd (NGIA). PHA assists its Members with a wide range of Emergency Plant Pest response preparedness activities that includes contingency planning.

A key part of preparedness for possible incursions of high risk pests is the development of contingency plans specific to each pest. Contingency plans can also form the basis for developing response plans in the event of detection of an exotic pest. Pest contingency plans thus assist with rapid emergency responses for eradication, containment or management of pest incursions.

This paper reports on the approach used to develop background information on pest biology and available control measures to prepare for an incursion of a range of viruses that are transmitted by whitefly vectors (Bemisia tabaci, Trialeurodes vaporariorum and T. abutilonia) into Australia. As this contingency plan was prepared for the nursery and garden industries, viruses posing of greatest economic impact and risk to the nursery industry were used as examples.

The contingency plan provides specific pest information for the Silverleaf whitefly (SLW, B. tabaci) vector, as well as examples from each of the major virus genera that are transmitted by whiteflies. Even though the focus of this contingency plan is exotic viruses transmitted by whiteflies, measures outlined involve control of the endemic whiteflies that would be vectors of the viruses in an incursion.

Pest specific information was illustrated using examples of viruses from the Begomovirus and Crinivirus genera that are considered relevant to the nursery industry. Where economically important exotic examples could not be found for a particular genus, non exotic examples were used. For example, even though the Begomovirus examples are present in Australia, they currently have a restricted geographic distribution and would be a much larger problem should they expand into the major tomato production regions.

The contingency plan for whitefly transmitted viruses provides a range of additional information. Technical information on planning surveys for the early detection of an incursion, delimiting surveys, collection and handling of SLW and virus samples are included. Chemical control and IPM options for SLW and the promotion of good farm management and farm hygiene practices of SLW are presented as options to manage the spread of whitefly transmitted viruses.
Preparedness for CLCuD in Australian Cotton.

By Cherie Gambley¹, Paul Grundy¹, Susan Maas², Murray Sharman¹, Linda Smith¹ and John Thomas³.

¹Department of Agriculture, Fisheries and Forestry, QLD (DAFFQ); ²Cotton Research and Development Corporation (CRDC); ³University of Queensland, Queensland Alliance for Agriculture & Food Innovation (QAAFI)

Cotton leaf curl disease (CLCuD) causes serious economic losses to cotton production in many regions where it occurs, in particular the Indian subcontinent. For example, CLCuD cost the Pakistan industry an estimated US$5 billion between 1992 and 1997. During the 2009-10 season losses of up to 100% were observed in many growing regions in India (Rajagopalan et al. 2012). CLCuD is not known to be present in Australia and represents a serious biosecurity risk. The disease was first recorded in Africa in the 1920s, in Pakistan and India during the 1990s and most recently in 2010 in China (Cai et al. 2010). The disease is present in Pakistan, India, Sudan, Egypt, Tanzania, Malawi and Nigeria. In Sudan during the 1950’s the disease caused yield losses of up to 40% (Tarr 1957 & Tarr 1964 in Malathi et al. 2003).

This presentation reports on the progress made for preparing the Australian cotton industry to potential incursions of this disease. Preparedness has included investment from the federal Department of Agriculture, Fisheries and Forestry (DAFF), the cotton industry through the Cotton Research and Development Corporation (CRDC) and the state Department of Agriculture, Fisheries and Forestry, QLD (DAFFQ).

The development of a National Diagnostic Standard for detection of the begomoviruses and associated beta satellites which cause CLCuD was funded by DAFF as part of the Subcommittee on Plant Health Diagnostic Standards (SPHDS) activities. The standard was submitted to SPHDS in 2011 and is to be published on the PADIL website (http://padil.gov.au/) once reviewed. Briefly, the protocol uses a modified CTAB extraction method with degenerate begomovirus DNA-A genome primers and degenerate DNA-beta satellite primers with subsequent sequencing of the PCR products for identification. The protocol compared several sets of degenerate primers for DNA-A amplification and recommends the use of either the Avcore/Accore primer set (Abdel-Salam, unpublished) or the SPG1/SPG2 primers (Li et al 2004). For amplification of the DNA-beta satellite the primers published by Bridden et al. (2002); β01 is used with a modified version of the β02 primer (β02M CCAGGGTGACACACCGCGC; Gambley unpublished). The assays are not limited to detection of the CLCuD-associated viruses and satellites and will amplify a range of other begomoviruses and associated beta satellites which are exotic threats, particularly to the vegetable and nursery industries. The diagnostic standard is yet to appear on the PADIL website; however, copies of the unreviewed version are available on request.

In a previous CRDC funded project there was extension material prepared for industry both as oral presentations and written articles for the industry best management guide,
conference posters and symptom guides. In addition a statistically based surveillance strategy was developed for in-field detection of the disease using the endemic Tobacco streak virus and Cotton bunchy top disease as model systems. The strategy was successfully trialled in India where CLCuD occurs. The strategy was also used to generate absence data for the Australian industry from 2009 to 2011. A major outcome of the project was a first draft of a contingency plan for CLCuD. The second draft of this plan will be prepared by July 2013.

Continuing on from this project, aims of a second CRDC funded project include the organisation and delivery of this workshop to increase awareness of exotic whitefly-transmitted viruses, promote cross-industry interest in managing these diseases if introduced and to review what management strategies are available to industry. In addition to this a review of potential live host imports into Australia is to be completed. This will focus on existing quarantine measures as listed on the ICON website (http://www.aqis.gov.au/icon32/asp/ex_querycontent.asp) and evaluation if these measures adequately mitigate possible entry of CLCuD. If mitigation measures are inadequate recommendations from industry to DAFF will be required on methods to close the pathway. A final aspect of the project is to develop an early detection surveillance strategy for whitefly-transmitted viruses using the vector as the survey target. The strategy uses a statistical based sampling strategy for collection of whitefly adults and molecular indexing to test the adults for exotic viruses and DNA beta satellites. A parallel project was proposed to the horticulture industry to fully resource the development of this strategy as the outcomes of the work will equally benefit this industry. However, the proposal to HAL was unsuccessful. Development of the strategy continues but results are limited due to lack of resources.

References


How Might an Outbreak of CLCuD Occur in Australia and Could it be Contained?

By Cherie Gambley and Paul Grundy.

Department of Agriculture, Fisheries and Forestry, QLD (DAFFQ)

CLCuD is not known to be present in Australia. However, with ever increasing importation of plant material, for trade and movement of people coupled with the widespread distribution of SLW throughout Australia’s eastern cropping regions, it could be argued that CLCuD presence is a significant future biosecurity threat for the Australian cotton industry.

As part of the development of preparedness measures for the event of a CLCuD outbreak we have considered the potential pathways whereby this begomovirus disease may gain entry into Australia and outlined the appropriate steps that may be taken in identifying and confirming a suspected outbreak.

Our hypothesis is that the most likely pathway by which CLCuD would gain entry is through the importation of live plant materials that are non-symptomatic and undetected via typical quarantine processes that rely heavily on visual diagnostics. Similarly un-official plant movements that occur with the passage of people through Australia’s northern regions also present a significant risk to Australia. Less likely passage may occur via extreme weather events such as monsoon lows or tropical cyclones whereby infected SLW adults may be transported over significant distances from parts of SE Asia to Australia.

We suggest that the most likely incursion scenario would be the post-quarantine detection of CLCuD within an intensive horticulture production facility that is linked to the production of newly imported alternative host plant cultivars. A good possibility for disease containment and eradication may exist for this scenario as the vector and the distribution of infected plant material maybe contained or outgoing material that could have been infected may still be traceable.

A less likely scenario but more serious is an open air outbreak within a cotton or horticultural crop. As CLCuD is not transmitted via planting seed, an open air outbreak of the disease in a crop is likely to indicate the presence of virus within the local environment which has been locally vectored into the crop. For this scenario we suggest that the possibility for containment and eradication is unlikely or at best very difficult. An effective response and determination of the likelihood for eradication would require a very rapid assessment of parameters including

- Location of outbreak in relation to broader industry
- Scale of outbreak both within local cropping and surrounding environment in non-crop hosts
- Trace forward and trace back data that might indicate the disease source or potential subsequent spread.
- Time of season and crop stage.

In the interim period, whilst these assessments are made it maybe prudent to conduct additional insecticidal control for SLW to limit the rate of virus proliferation in the local environment.
In the event that the outbreak is found to be localised but widespread between fields and non-crop hosts the most effective strategy maybe to transition industry to a field management approach. Tactics would include limiting spread where possible to other regions by limiting the movement of host plants. An increased emphasis on farm hygiene particularly between seasons would be critical although the additional spraying of SLW in an effort to contain vector activity is unlikely to succeed in reducing the virus spreading and would likely contribute to an increase in insecticide resistance.

A key focus once CLCuD became established within a growing region would be to limit subsequent spread to other regions which would buy valuable time and allow plant breeders to make varietal selections for improved host plant resistance. Host plant resistance is one of the few longer term management strategies available and is likely to be beneficial when combined with farm hygiene, crop rotation with non-hosts and improved SLW management. Host plant resistance mechanisms may be more stable in Australia than has been the experience in countries like Pakistan as comparatively, Australia has a very low background diversity of begomoviruses, and thus fewer opportunities exist for virus evolution through recombination.

Clearly preventing the entry of this disease should be a high priority and requires increased awareness in state and federal biosecurity agencies and in the ornamental, horticulture and cotton industries. Trade in live host plants remains the most likely pathway into and around Australia.