Aspects of vector thrips biology and epidemiology of tospoviruses in Australia

Clift AD[1] and Tesoriero L[2]
[1]Dept of Crop Sciences, The University of Sydney, NSW 2006 Australia; [2]EMAI, NSW Agriculture, LB 8 Camden, NSW 2570, Australia
E-mail: CliftA@agric.usyd.edu.au

Introduction

Spotted wilt was first described from Australia on tomatoes in 1915 (Brittlebank, 1919). Pittman (1927) showed that this disease was caused by a virus and could be transmitted by *Thrips tabaci* (onion thrips). Subsequently, Samuel et al. (1930) working on Tomato Spotted Wilt Virus (TSWV) from South Australia reported *Frankliniella schultzei* (tomato thrips) as a vector of the disease. TSWV occurs commonly in vegetable crops in Australia, but rarely at levels exceeding 2% (Tesoriero *et al* 1996).

In 1918/19 high levels of TSWV occurred throughout the state of Victoria, with up to 50% of plants affected (Brittlebank 1919). Other early reports on the incidence of TSWV were summarised by Samuel et al. (1930): the 1928/29 season appears to have been significant throughout south-eastern Australia, with severe infections recorded in tomatoes in Sydney, Melbourne and Adelaide. A major epiphytotic was recorded in 1945-47 on the Southern and Central Tablelands of NSW (Conroy et al 1949), with up to 100% infection recorded in potato crops.

In 1993 *F. occidentalis* (western flower thrips) was found in both Western and Eastern Australia (Tesoriero et al. 1996). In the summer of 1994-95, vegetable crops in NSW, Victoria, SA and Qld were infected with higher levels of TSWV (Tesoriero et al 1996). The incidence of TSWV in Australian native plants, weeds and crops was intensively surveyed in WA in the same season (Latham and Jones 1997). In both reports, the three vectors *T. tabaci, F. schultzei* and *F. occidentalis* were implicated to varying extents.

Using observations published in agricultural newsletters, the (Australian) Western Flower Thrips Newsletter, articles published in workshops and journals plus our own data, the available information in Australia on vector thrips and TSWV incidence to the end of 2000 has been collated. Inferences derived from this information are presented and discussed in relation to vector thrips biology and epidemiology of tospoviruses in Australia.

Review of Australian data

TSWV has been found in a range of vegetables and cut flowers throughout Australia (Fig. 1), and occurs in association with a range of thrips.

Tasmania

In the Coal River Valley, Tasmania, the main vector is *T. tabaci*, (Wilson 1995), although *F. occidentalis* does occur occasionally in glasshouse crops and adjacent strawberry plantings (Hill 2000). Regarding TSWV, *T. tabaci* is still the only field vector. TSWV was found in a mixed stand of white and subclover (Wilson1995).

Figure 1. Map of Australia

Western Australia

Prior to the arrival of *F. occidentalis* in 1993 (Malipatil *et al* 1993), *T. tabaci* was presumed to be the only TSWV vector (Latham *et al* 1997) in Western Australia. The arrival of *F. occidentalis* resulted in a major increase in TSWV incidence in the area between Carabooda to the north of Perth, south to Rockingham, (Fig. 1), basically the Swan River Valley (Latham *et al* 1997), but at least one incidence of *F. schultzei* and TSWV was found in lettuce.

Detailed determinations of disease incidence within paddocks has indicated the classic high levels at one side, falling off further into the crop (Latham et al 1997). Widespread examinations of potential hosts have defined the main weed hosts of TSWV in Western Australia, with thistles and capeweed being the main hosts (Latham et al 1997). TSWV at low incidence, *F. schultzei* and *T. tabaci* occur in the major potato growing areas near Albany and Manjimup, south-west Western Australia (Figure 1)(Thomas and Jones 2000).

South Australia

The two study areas in South Australia are the North Adelaide Plains, centred on Virginia, growing mixed horticulture, glasshouses, fields and orchards and Mt Gambier, where substantial areas of potatoes are grown. While all three vectors were present around Virginia during the 1999/2000 season (Bailey and Caon 2000), TSWV levels in a range of crops, including potatoes, was high. Moderate levels were present in potatoes at Mt Gambier, where the main vector appeared to be *T. tabaci*, (Bailey and Caon 2000).

Victoria

In Victoria, the two main areas affected are horticultural production areas around Melbourne, and the irrigation areas in the north of the state (Fig. 1). The main vector species are *T. tabaci* in the irrigation areas, and *F. occidentalis* in a patchy distribution around Melbourne. TSWV levels in processing tomatoes in the northern areas rarely exceeds 3% (Bentley 1998).

One reasonably well understood instance of TSWV and *F occidentalis* occurred in glasshouse capsicum production. The grower privately admitted to introducing a recently purchased potted gerbera plant which probably was infested with both organisms into an empty glasshouse. Capsicum seedlings were planted into the glasshouse a few weeks later, with severe levels of infection by flowering.

F occidentalis was reported from glasshouse and field capsicum, chilli and eggplant in the Mildura area, an inland irrigated production area in 1999 (Gillespie 1999) (Fig. 1). TSWV was severe in some of the crops. *T. tabaci* is common in the area.

Queensland

Only two of the many potential areas in Queensland were monitored over the time interval considered here, although observations have been made in other areas. These were Redlands Bay area (Hargreaves 2001) and Bowen area (Abbott 1999). Although *F. occidentalis* is present in the horticultural production areas of Redlands Bay (Figure 1), there it does not seem to be associated with TSWV (Hargreaves 2001). The main vector at Bowen is the yellow morph of *F. schultzei* (Abbott 1999), where the thrips move into the irrigated crops during the dry season of the dry tropics (Fig. 1). TSWV has reached levels of up to 40 in capsicums during 1999 and 2000 (Persley 2001). In the 1994/95 season at Redlands Bay, *T. tabaci* appeared to be the main vector (Tesoriero 1995). *F. occidentalis* caused feeding damage to apples, stonefruits and capsicum in the Stanthorpe area (Hargreaves 2001) (Figure 1), as well as vectoring TSWV in capsicums (Persley *et al* 2001)

In 1999, a new tospovirus from Serotype IV, termed Capsicum Chlorosis Virus, CaCv, was reported from the Bundaberg area, infecting capsicum, chilli and tomatoes; TSWV was also present (Persley 2001). Both the yellow morph of *F. schultzei* and *F. occidentalis* occur in the Bundaberg/Childers area and their vector status is unknown (Hargreaves 2001) The usual vector associated with this group of viruses is *Thrips palmi* Karny, present in the area. The yellow form of *F schultzei* is also common in the area.

New South Wales

The situation in NSW has been studied over a wider area than in the other states (Figure 1). Observations in the Crookwell area (Tesoriero et al 1994) indicated that between 1992/93 and 1993/94, *T. tabaci* was the main vector species and was usually associated with below 3% TSWV in seed potato, but that two crops with *F schultzei* as the vector recorded over 50% infection (Tesoriero et al. 1994). During the 1994/95 season, the irrigation areas around Griffith (Fig. 1) recorded over 90% infection in lettuce and capsicum and up to 30% in processing tomatoes (Tesoriero et al. 1995); the vector in each case was *F. schultzei.* This was a consistent infestation over an area at least 100 by 20 km, yet irrigation areas to the west and south west were largely uninfected.

In 1996/97, *T tabaci* was the vector responsible for 7–16% infection in processing tomatoes in Jerilderie (south of Griffith, Figure 1) (Bentley 1998). In this situation, the disease incidence was determined in each of the four corners and in the centre of the paddock: the infection levels in the centre were higher than at the corners (Bentley 1998), suggesting a widespread migration in of viruliferous thrips, rather than diffusion from one side. The only weed hosts infected with TSWV in the area were variegated thistle and oxtongue

Detailed monitoring in market gardens in the western part of the Sydney Basin indicated that low density populations of *F occidentalis*, with no detectable levels of TSWV could be found in hydroponic lettuce and capsicum/chilli crops. Throughout the year variable numbers of *T tabaci* would fly into the farms and a low proportion of these would be carrying TSWV (Clift *et al* 2000). Between 1996 and 2000, this happened on five farms out of eight monitored.

The first instance was on a hydroponic lettuce grower, March 1997, who raised his own seedlings and also had a high incidence of weed hosts of TSWV. Initially there were low–moderate *F occidentalis*, but no TSWV. By May 1997, TSWV was present. The TSWV rapidly infected the sowthistle surrounding the seedling trays. The final result was a population of viruliferous *F occidentalis* infecting the growing lettuces, plus a proportion of infected seedlings were transferred out into the main cropping area. In June, up to 20% of the lettuce plants were infested and by December, over 80% infection was found.

The second instance was on a mixed conventional farm, growing capsicum and lettuce, with a poorly managed horse paddock next to the cropping area. The only vector thrips present on the farm was *T tabaci*. There was only one capsicum crop infected with TSWV in March 1998, about 10% plants infected, but the crop was adjacent to the horse paddock. Roguing out infected plants assisted in minimising the infection levels and confined the infection to the one crop.

The third instance involved hydroponic tomatoes, in September 1998. The only vector species was *T tabaci* and less than 1% plants were infected. These were rogued out and the infection halted.

The fourth instance was more severe, in hydroponic lettuce, February 1998. Regular monitoring indicated low *F occidentalis* numbers and no TSWV, but low numbers of *T tabaci* were also regularly trapped. Over a three week interval during February 1998, virtually 100% of the lettuce plants on one side of the farm, adjacent to an open loading area became infected and at the same time, *F occidentalis* numbers also increased. While it was possible infected thrips could have been brought in on the trucks collecting produce, the infected area was at the opposite end to where the trucks parked and were loaded.

The fifth instance was on a mixed conventional farm, growing mainly capsicum over the spring and summer months. Monitoring started August 1999. There was a mixture of *F occidentalis* and *T tabaci* and in October 1999 some TSWV infected capsicum plants were noted. These were rigorously rougued out and the *F occidentalis* did not appear to acquire the TSWV. Although both vector thrips species were present at least until June 2000 on crop plants, white clover and weeds, no further instance of TSWV was observed.

Discussion

Throughout Eastern Australia, 1994/95 seemed to be a bad year for both TSWV and thrips. In SA, *F. schultzei* and more recently *F. occidentalis* were present, but in Tasmania, *T. tabaci* was the only vector associated with major crop losses. In Victoria *T. tabaci* and *F. schultzei* were both found, and in NSW all three, *T. tabaci*, *F. schultzei*, *F. occidentalis*, were present. Recently all three were also implicated in Queensland. Both *T. tabaci* and *F. schultzei* were found to migrate readily into areas, sometimes bringing TSWV with them. *F. occidentalis* was less mobile, with most movement on infested material.

One management option for hydroponic and glasshouse/polyhouse growers is to use grass only under the racks or between the glasshouses. A selective herbicide can be used to eliminate clovers and weeds, leaving the grass to prevent soil erosion and restrict the growth of new weeds. There is clear evidence (Clift 2000) that *F. occidentalis* is easier to manage in the absence of weeds and clovers. Field trials indicate chemicals are relatively more effective when weeds are not present. Conversely, if clovers and weeds are abundant, it is not possible to manage *F. occidentalis* with insecticides alone.

Both *T. tabaci* and *F. schultzei* migrate in Australia, often over long distances (Wilson and Bauer 1993) and have a significant role in perpetuating TSWV in a wide area, including bringing the virus into new districts/properties. There is no local defence against large migrations, covering thousands of square kilometres, of thrips infected with TSWV. *F. occidentalis*, which does not migrate well on its own and usually moves with infested material, is therefore better suited to spreading an existing infection.

In three cases of TSWV in the 1998/99 season, *T. tabaci* was the only known vector species found in numbers previously on the property. The other incidence was associated with *F. occidentalis*, but this species had been continuously present for the preceding several months. *T. tabaci* had also come onto the farm in discrete migrations and one of these may have introduced the disease. Once on the farm, TSWV could then be spread by *F. occidentalis*. A detailed examination of 15 weed species growing on the farm in Sept/Oct 1998 failed to find TSWV, but in March/April, Cobblers peg proved to have severe TSWV.

Although *F. occidentalis* has been present in the Sydney area since at least October 1993, its distribution is still very patchy and most infestations in NSW outside the Sydney area appear due to movement of infested material, rather than direct thrips migration. Observations from 1993 in Western Australia (Malipatil *et al* 1993) indicate *F occidentalis* does not compete well in unsprayed situations. The absence of *F. occidentalis* from large areas of unsprayed flowering weeds also suggests this thrips cannot compete well against existing thrips populations in an unsprayed environment.

Four basic scenarios are proposed for TSWV transmission:

1. Viruliferous thrips move into a crop, essentially a local, within farm situation (Latham *et al* 1997, Abbott 1999, Hargreaves 2001).
2. Major migration of viruliferous thrips moves into a large area, as found in NSW in the 1994/95 season (Tesoriero et al 1995, Bentley 1998, Clift et al 2002).
3. A mobile vector species brings the TSWV onto a farm and a resident *F occidentalis* population acquires it and spreads it round the farm has now been reported from the Sydney basin (Clift *et al* 2000). This scenario could be common in the North Adelaide Plains area and the Swan Basin, Western Australia.
4. Infected seedlings have been reported from the Swan Basin (Latham *et al* 1997) and has been observed in Victoria, Queensland (Hargreaves 2001) and in the Sydney Basin (Clift *et al* 2000).

Conclusions

In Australia, three thrips vector species are associated at least part of the time with TSWV. *T palmi* was associated with a different tospovirus, Capsicum Chlorosis Virus, but the role of the other vector species is not understood. Behavioural differences between the thrips species means different management practices are required. The two *Frankliniella* species appear to be more efficient vectors of TSWV, but *T. tabaci* clearly has a role in bringing TSWV onto properties. *T. tabaci* will infest and breed on small seedlings, whereas *Frankliniella* species are flower thrips, with highest numbers and greatest movement into flowering crops. While it is not possible to prevent migrating species arriving on farms, *T. tabaci* and *F. schultzei*, regular monitoring, accurate identification, maintenance of farm hygiene, and intelligent use of insecticides will minimise the establishment and spread of thrips and TSWV. Management of flowering non-crop hosts is the main key to managing TSWV and *F. occidentalis*.

Acknowledgments

The field work for 1996 was funded by NSW Agriculture . The work in 1997/98 and 1998/99 was funded by the HRDC (now HAL) National Strategy for managing thrips and tospoviruses.

References

Abbott S. 1999. Bowen Crop Monitoring Services and an IPM strategy to reduce TSWV in the dry tropics. *Western Flower Thrips Newsletter* **15**, 30-32.

Bailey P and Caon G. 2000. Thrips and TSWV in South Australia. *Western Flower Thrips Newsletter* **20**, 6.

Bentley J. 1998. IPM strategies for control of TSWV in processing tomatoes. *Western Flower Thrips Newsletter* **11**, 36-37.

Brittlebank CC. 1919. A new tomato disease, spotted wilt. *Journal of Agriculture, Victoria* **27**, 231-235.

Clift AD, Cannard M and Ryland A. 2000. Management of thrips and TSWV in the Sydney Basin. *Western Flower Thrips Newsletter* **20**, 18-22.

Clift AD, Singh P, Bowyer J, Rose H, Tesoriero L, Beattie GAC and Rajakulendran V. 2002. Use of horticultural mineral oils to control tospovirus and phytoplasma-associated diseases of tomato. *IN* "Spray oils beyond 2000 – University of Western Sydney" Eds: Beattie, GAC, Watson, DM, Stevens, ML, Rae, DJ and Spooner-Hart, R.

Conroy RJ, Shirlow LS, Wilson RD and Waring EJ. 1949. Tuber transmission of spotted wilt disease of potatoes. *The Agricultural Gazette of NSW*: 101-103.

Gardner R and Kulkarni S. 1998. Thrips in Victoria. *Western Flower Thrips Newsletter* **11**, 28

Gillespie P. 1999. Thrips in New South Wales. *Western Flower Thrips Newsletter* **18**, 4.

Hargreaves J. 2001. Thrips in Queensland. *Western Flower Thrips Newsletter* **21**, 4.

Hill L. 2000. Thrips in Tasmania. *Western Flower Thrips Newsletter* **20**, 4.

Latham LJ and Jones RAC. 1997. Occurrence of tomato spotted wilt tospovirus in native flora, weeds and horticultural crops. *Aust. J. Agric. Res.* **48**, 359-369

Malipatil MB, Postle AC, Osmelak JA, Hill M and Moran J. 1993. First record of *Frankliniella occidentalis* (Pergande) in Australia (Thysanoptera: Thripidae). *J Aust ent Soc*. **32**, 378

Persley D, McMichael L, Sharman M, Thomas J and McGrath D. 2001. Tospoviruses and capsicum in Queensland. *13 APPS Nat. Conference, Cairns, 2001.*

Pittman HA. 1927. Spotted wilt of tomatoes. *Journal of CSIR, Australia* **17**, 74-77

Samuel G, Bald JG and Pittman HA. 1930. Investigations on Spotted Wilt of Tomatoes. *CSIR, Bulletin* **44**, 1-64.

Tesoriero L, Clift A and Gillings M. 1994. Rapid detection, epidemiology and control of TSWV in seed and processing tomatoes – Final Report, PT 101, NSW Agriculture, 28 pp.

Tesoriero L, Rajakulendran V, Clift A and Moran J. 1995. Elevated levels of Tomato Spotted Wilt Virus in vegetable crops in Eastern Australia in 1994/95. *IN* '*Proceedings of 1995 Australian and New Zealand Thrips Workshop*' (Eds S. Goodwin and P. Gillespie) 27-30

Thomas M and Jones R. 2000. TSWV in Potatoes. *Western Flower Thrips Newsletter* **20**, 9.

Wilson CR. 1995. Tomato spotted wilt virus – a serious threat to Tasmanian horticulture? *IN* '*Proceedings of 1995 Australian and New Zealand Thrips Workshop'* (Eds S Goodwin and P Gillespie) 31-32

Wilson LJ and Bauer LR. 1993. Species composition and seasonal abundance of thrips (Thysanoptera) on cotton in the Namoi Valley. *J Aust ent Soc.* **32**, 187-192