The rise and rise of *Bactericera cockerelli* in potato crops in Canterbury

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Abstract Tomato potato psyllid (TPP), *Bactericera cockerelli* (Šulc) (Hemiptera: Trioizidae), was first recorded in the North Island of New Zealand in 2006. Three years later, the insect was found in the Oamaru area (South Island). Over the years there has been a rise in TPP numbers trapped in potato crops in Canterbury (South Island). Recently, increased prevalence and severity of foliar and tuber symptoms related to plant infection with *Candidatus Liberibacter solanacearum* (CLso), vectored by TPP, have been observed in trials and in commercial potato crops. Moreover, in the 2013–14 season the resulting zebra chip disease was observed for the first time in tubers at a processing plant in Canterbury. It is concluded that Canterbury has a landscape where hosts are available year-round and a climate that does not seem to hinder TPP development. The aim of this paper is to present a stocktake of TPP in Canterbury.

Keywords tomato potato psyllid, *Candidatus Liberibacter solanacearum*, zebra chip disease, trapping, disease symptoms, Canterbury.

INTRODUCTION

Tomato potato psyllid (TPP), *Bactericera cockerelli* (Šulc) (Hemiptera: Trioizidae) is widely distributed in North and Central America (see EPPO 2013 for details on countries). In 2006 TPP was first reported in New Zealand (Gill 2006). In 2008 in New Zealand, the insect was associated with a new-to-science pathogen, *Candidatus Liberibacter solanacearum* (CLso) (Liefting et al. 2008). This pathogen is the putative causal agent of zebra chip (ZC) disease of potato tubers (Liefting

et al. 2008), which makes them unsuitable for processing (Secor & Rivera 2004; Munyaneza et al. 2007), causes disease in seed tubers (Berry et al. 2011; Pitman et al. 2011), and is perceived to affect the taste of fresh market potatoes as well as their internal appearance. The insect/pathogen complex is also an important economic pest of other solanaceous crops, including outdoor and greenhouse tomato and capsicum, tamarillo and eggplant.

TPP was first reported from a specimen collected in a tomato greenhouse complex at Clevedon (Auckland, regions after Crosby et al. 1998) in New Zealand in March 2006 (Teulon et al. 2009). By May of that year, a delimiting survey conducted in the wider Auckland region had detected TPP in several glasshouse facilities and also on outdoor crops (Gill 2006). The first report of TPP in the South Island was made in June 2007 (Nelson region; Teulon et al. 2009). In February 2008 the insect was found in the Mid Canterbury region and by January 2009 it was found as far south as Oamaru (Dunedin region; Teulon et al. 2009). In the period January to March 2012 low numbers of TPP were trapped on yellow sticky traps in Southland (Dohmen-Vereijssen et al. 2012). The aim of this paper is to present a stocktake of TPP in Canterbury, focusing on its spread and increase in abundance since 2008.

MATERIALS AND METHODS

Trapping of TPP adults was performed nationwide in the 2009–2012 growing seasons in the National Monitoring programme (SFF09/143), but only the trapping data from potato crops in South, Mid and North Canterbury were used for this paper. Double-sided yellow sticky traps (BugScan®, 25 cm × 10 cm) were mounted on bamboo stakes just above plant height. Traps were placed 5 m from the field edge at each cardinal direction. Traps were collected and replaced weekly and sent to Plant & Food Research (PFR) Lincoln, where staff would identify and count TPP on traps using a stereomicroscope (0.63–4 × magnification). From the 2012–13 growing season onwards, in other research programmes, an additional sticky trap was placed in the centre of a crop (five traps/crop). These trials were conducted in Mid and North Canterbury. Trapping results are presented in number of TPP/trap/week.

Accumulated degree days (DD) were calculated from hourly mean temperatures using Min and Max dry bulb (NIWA CliFlo) from 1 July onwards, as described by Butler et al. (2013). In New Zealand, Tran et al. (2012) estimated from laboratory studies that the time from egg oviposition to adult

emergence on potato was 358 DD for temperatures above a lower threshold of 7.1°C. From this, the number of potential generations of TPP per year in a region can be calculated.

RESULTS AND DISCUSSION

There is a common impression among industry sources and scientists that the abundance of TPP has increased in Canterbury since 2008, and this is supported by weekly trapping data (Figure 1). In the growing seasons from 2009 to 2012, larger numbers of TPP/trap/week were trapped in solanaceous crops in the North Island than in the South Island (Dohmen-Vereijssen et al. 2012). The colder southern climate was suggested as the main factor limiting the build-up of large numbers of TPP. In particular, TPP were thought to suffer mass mortality in subzero temperatures. However, all TPP life stages were present on *Lycium ferocissimum* Miers and *Solanum aviculare* Forst during autumn and winter host surveys in frost-prone Hawke's Bay (Taylor & Berry 2011) and this was later confirmed for Mid Canterbury (Vereijssen & Scott 2013). The non-crop solanaceous host plants cannot only harbour TPP in winter, but also serve as reservoirs of CLso (Murphy et al. 2014; J. Vereijssen, unpublished data). It is now known that TPP life stages can survive frost temperatures. Whipple et al. (2012) found that a temperature of -16°C for 6 h was required to achieve 50% mortality (lethal time: LT₅₀) in both nymphal and adult TPP collected in Nebraska and Washington, based on placing insects in a Percival environmental chamber at different temperatures for up to 24 h. Nymphs often required colder temperatures to reach LT₅₀ than adults. Some, albeit slow, development of nymphs has been observed in winter in Canterbury, so it appears that the distribution of TPP may not be limited by the relatively cool temperatures experienced throughout many areas of New Zealand (J. Vereijssen, unpublished data).

In the 2013–14 season, mean weekly trap catches of adult TPP in a PFR potato spray trial at Lincoln (Mid Canterbury) were generally higher than in a similar trial in Pukekohe (Auckland). Also, the action threshold of 3 TPP/trap/week

Figure 1 Mean adult tomato potato psyllid (TPP) per yellow sticky trap per week during the growing seasons since first occurrence of TPP in Canterbury, New Zealand. 2008–09: n=3 potato fields; 2009–10: n=16; 2010–11: n=20; 2011–12: n=8; 2012–13: n=3; 2013–14: n=3; 2014–15: n=2.

(Walker et al. 2013) was reached earlier in Lincoln than in Pukekohe (Vereijssen et al. 2014). This could not be explained by accumulated DD from 1 July in that season, which were lower for Lincoln than for Pukekohe during the growing season, thus fewer generations of TPP had been expected in Lincoln. The 2013–14 season appeared to be the first time that TPP numbers on sticky traps in PFR potato trials were higher in Lincoln than in Pukekohe. This was accompanied by severe foliar symptoms putatively caused by CLso in the Lincoln trial and three trials in commercial fields in Mid Canterbury. However, none of the almost 100 adult TPP caught on plants in the Lincoln trial tested positive for CLso (Vereijssen et al. 2014) using qPCR (Beard et al. 2013), although a fry test for ZC disease showed tubers in the trial were infected. The discrepancy between undetectable CLso levels in the vector and the uniformity and severity of the disease symptoms remains unresolved, unless there had been CLso-positive TPP around just after emergence. The 2013–14 season was also the first time tubers grown in Canterbury affected by ZC disease were observed at a process plant in Canterbury (S. Clelland, McCain Foods, personal communication).

In the 2014–15 season in PFR potato spray trials, trap catches were again on average higher in Southbridge (Mid Canterbury) than in Pukekohe. The action threshold of 3 TPP/

trap/week was reached around the same date in Southbridge and Pukekohe despite there being fewer accumulated DD in Southbridge. Similarly in the 2013–14 season, severe CLso foliar symptoms were observed in a range of commercial crops and PFR trial plots in eastern, coastal Mid Canterbury. Even a commercial early crop (planted in September, harvested before the end of December) in coastal North Canterbury was heavily infested with TPP and showed severe foliar CLso and raw tuber ZC disease symptoms by mid-December. These symptoms progressed rapidly and by the end of December were almost uniform throughout the crop (J. Vereijssen, unpublished data).

Feedback from industry sources in the 2014–15 season was that fewer TPP adults were caught on sticky traps in Canterbury than in the 2013–14 season. Despite that, zebra chip symptoms were being seen in raw tubers from early March 2015 onwards (S. Clelland, McCain Foods, personal communication; J. Vereijssen, unpublished data).

In contrast to Canterbury, numbers of TPP trapped on yellow sticky traps in Hawke's Bay have declined over the last 2–3 seasons (N.M. Taylor, unpublished data). The low trap catches in Hawke's Bay in the 2014–15 season may in part be explained by low DD accumulation since 1 July (the lowest since 2006) and the removal of perennial TPP host plants.

Effect of increasing TPP numbers on different potato cropping sectors

The process potato growers are acutely aware of TPP/CLso, as their crop can be rejected at the process factory when the ZC percentage exceeds the threshold (on average, 1.5–2% tubers with ZC in a crop). With this in mind, Potatoes NZ (PNZ) and PFR established a TPP monitoring programme in 2009 (MPI Sustainable Farming Fund 09/143) to assist with the growers' spray decision-making. In addition to improving management of TPP and consequently ZC disease, PNZ has advised that growers must use a rotation of pesticide modes of action to reduce the development of insecticide resistance in potato pests. The increase in reports of raw tuber ZC disease symptoms in this 2014–15 season will prove a challenge for TPP management in the coming growing season.

Fresh market potato growers in Canterbury have not experienced the severity of the TPP/CLso problem to the extent that process potato growers have, and there has not been a direct effect on fresh market tuber quality or yields. However, this may be about to change. In the 2014–15 season undersized tubers and raw tuber ZC disease symptoms were observed throughout the first 10–15 m of plantings in a mature commercial fresh potato crop where TPP infestation was high and severe CLso foliar symptoms were present early in the growing season. CLso infection of the tuber is perceived to affect taste, and the effect of the increased insect numbers and foliar symptoms may start to have an impact on the quality of fresh market potatoes in Canterbury.

The severe TPP and CLso infestation in the North Island has resulted in most seed potato production being focused in Canterbury. The increasing TPP/CLso problem in Canterbury is now a concern for the local seed potato growers, seed merchants and the New Zealand Seed Potato Certification Authority (NZSPCA). Scattered CLso-infected plants, exhibiting potato leafroll virus-like symptoms, at very low incidence (below the incidence of current virus certification tolerances) are appearing in certified seed crops. This suggests that secondary infection of CLso from the previous season may be occurring in

these crops. Consequently, the NZSPCA now requires these rogues to be recorded and removed in the 2016 season.

What to expect for the future in Canterbury?

From the present observations in east Mid Canterbury, it seems that TPP and CLso prevalence are increasing. Similar numbers of TPP/trap/week to those previously caught in Auckland and Hawke's Bay are now being trapped, and this will be of concern to the potato industry. In the last 2 years the conflicting trends observed between Canterbury on the one hand, and Hawke's Bay and Auckland on the other, could not be explained just by using climate (DDs). Three possible reasons for this are presented. Firstly, Auckland and Hawke's Bay may have reached the TPP carrying capacity of the environment (Schowalter 2006): TPP may have invaded all resource supplies and the intensity of competition with other species, including predators may be in equilibrium now. Secondly, growers may have learned how to manage TPP more effectively and consequently reduced numbers in the area. Thirdly, there may have been a reduction in the number of untreated crops and/or suitable weed hosts, which have been removed by growers as a result of adoption of research findings.

With the increase in numbers of TPP caught per sticky trap per week, discovery of ZC-affected tubers at the process plant, and secondary infection in some seed crops, could Canterbury be in the positive acceleration/exponential phase of the TPP and disease growth curve? The data show that Canterbury has a landscape where hosts are available year-round and a climate that does not seem to hinder TPP development. Future research should focus on weed and volunteer management, production of clean seed, TPP/CLso-resistant or tolerant potato cultivars, and effective reduced spray programmes for a more sustainable potato production and reduced insecticide resistance pressure.

Conclusion

After 7 years of research, the TPP/CLso problem has not been resolved in Canterbury. There is

evidence (Figure 1) that since 2008 the number of TPP trapped per yellow sticky trap per week in Canterbury has increased. It is hard to pinpoint factors that may have contributed to this increase in pest and disease pressure, especially in the eastern, coastal area of Mid Canterbury. There are still many knowledge gaps, and future research will aim to further understand TPP population dynamics during the year. Approaches will include vector modelling; landscape ecology; developing sustainable management practices of TPP in Canterbury and other potato growing regions for each of the potato cropping sectors; developing insecticide resistance management strategies; and breeding TPP/CLso-resistant or tolerant potato varieties.

ACKNOWLEDGEMENTS

We thank all the growers, property owners, crop scouts and agronomists for their participation over the last 7 years. The authors would like to acknowledge the support of the MPI Sustainable Farming Fund (09/143 and 11/058), Plant & Food Research Core funding (CAP10–72), Potatoes NZ and the Australian Government's Cooperative Research Centres Program (CRC2079). Thank you to David Logan, Melanie Davidson, Sue Zydenbos and an anonymous reviewer for helpful comments on the manuscript.

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