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PFR SPTS No. 15448

End-of-season and post-desiccation management options for tomato potato psyllid (*Bactericera cockerelli*) in potato crops in Canterbury

Furlong JN, Connolly P, Vereijssen J

September 2017















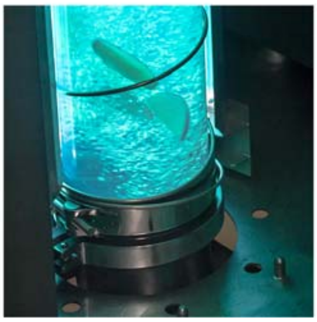


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August 2017

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CONTENTS

EXECUTIVE SUMMARY

End-of-season and post-desiccation management options for tomato potato psyllid (*Bactericera cockerelli*) in potato crops in Canterbury

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September 2017

The five potato field trials described in this report were funded through levies from Potatoes New Zealand Incorporated, which are managed by the Foundation for Arable Research (FAR). These trials were designed to test end-of-season and post-desiccation management options in potato crops for control of the tomato potato psyllid (TPP) insect pest, *Bactericera cockerelli* (Šulc), and zebra chip (ZC), a disease caused by the pathogenic bacterium *Candidatus* Liberibacter solanacearum which TPP transmits while feeding. An insecticide programme without organophosphates, neonicotinoids or (synthetic) pyrethroid insecticides was to be implemented throughout the growing season in six potato crops in Canterbury, New Zealand in 2016–2017. Then at desiccation, three treatments and a control were to be applied in treatment strips within each crop, trialling three different combinations of an oil (JMS Stylet oil) and/or an organophosphate (Methafos) application with mechanical potato haulm destruction (flailing).

Tubers collected by hand in these crops before and after desiccation, along with commercially harvested tubers sampled from trucks at the process factory, were fried and scored using ZC or fry colour assessment scales. TPP were trapped throughout the growing season in three crops. Because of field conditions and/or grower discretion, applications of the insecticide programme and desiccation treatments did not follow original plans and led to incongruent site spray logs, when available. Therefore, results were not compared between treatments within a site and across sites and no recommendations regarding the efficacy of the new insecticide programme or post-desiccation treatments can be formulated.

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1 INTRODUCTION

Since its 2006 detection in New Zealand, the tomato potato psyllid (TPP), *Bactericera cockerelli* (Šulc), has been responsible for reductions in yield and quality in potato crops, as well as in other solanaceous crops (Teulon et al. 2009). TPP acts as the insect vector for the bacterium *Candidatus* Liberibacter solanacearum (CLso), which is the putative agent of zebra chip (ZC) disease in potatoes and leads to dark patterns appearing during fry and crisp production (Munyaneza et al. 2007). This unwanted darkening affects quality and marketability through taste, texture and aesthetics. Additionally, even in the perceived absence of CLso, TPP feeding is linked to lower marketable tuber numbers, reducing yields and profits (Munyaneza et al. 2008), as well as an increase in unmarketable tuber numbers (Furlong et al. 2017).

Current methods for controlling TPP rely heavily on frequent broad-spectrum insecticide applications throughout the growing season, as Integrated Pest Management (IPM) strategies continue to be developed (Butler & Trumble 2012; Jorgensen et al. 2013; Teulon et al. 2009). While the group of process potato growers hosting these trials communicated, prior to planting in 2016, that they were generally satisfied with spray programmes keeping TPP under control during the majority of the growing season, concerns were expressed about end-of-season TPP management. Flare-ups of TPP populations were often seen in the late season (mid-February–March) by growers when using stronger chemicals, such as organophosphate (OP) or neonicotinoid insecticides, during those months. Additionally, during the desiccation period (as growers may desiccate multiple times) growers were concerned about regrowth creating opportunities for TPP feeding and CLso transmission to tubers at the very end of the season, which can result in ZC after a month in storage.

These trials were designed to address grower concerns regarding TPP management during the mid to late growing season and after desiccation. Growers indicated seeing a flare up of TPP when harsher insecticides (e.g. organophospates) were used. Also, regrowth has been an issue for the last two years and a new management option for dealing with regrowth was needed.

1.1 Aim

The aim of this study was to test a softer insecticide programme, specifically excluding organophosphate and neonicotinoid insecticides, for TPP management in potatoes throughout the growing season in Canterbury. Additionally, end-of-season TPP management options were to be reviewed by testing three desiccation treatments with differing combinations of oil and/or organophosphate applications plus mechanical potato haulm destruction (flailing).

2 MATERIALS AND METHODS

2.1 Trial sites and design

Trials were laid out in five crops (25 –37 ha), near Ashburton (three crops) and Temuka (two crops), growing Russet Burbank potatoes for McCain Foods Limited for a 2017 harvest (Figure 1). Each site was planted with a single seed line of Russet Burbank, reducing variation within a site, however seed lines varied between sites. Originally, six crops were assigned to the trial, but Site 3 was dropped at the request of the grower. In each crop, four treatment strips were created over the length of the crop either straddling (24 m) or centred (32 m) between tramlines, depending on tramline spacing. This was to accommodate growers for ease of spraying and to ensure at least one truck at harvest could be filled from each of the treatment strips for bucket samples and commercial assessments at the McCain process factory. Treatment strip size varied with site shape and size, but treatment strips were about 2 ha each.

A single plot (50x50 m) was set inside of each treatment strip, designating an area for hand-sampling of tubers (Figure 2). The single plots were set at least 50 m into the treatment strip and from access roads to reduce edge effects and were staggered as appropriate with consideration to uniform areas free of noticeable soil, planting, slope or moisture variation. Four bamboo poles with flagging tape, set low enough to stay under a spray boom, marked the corners of the plots throughout the season.

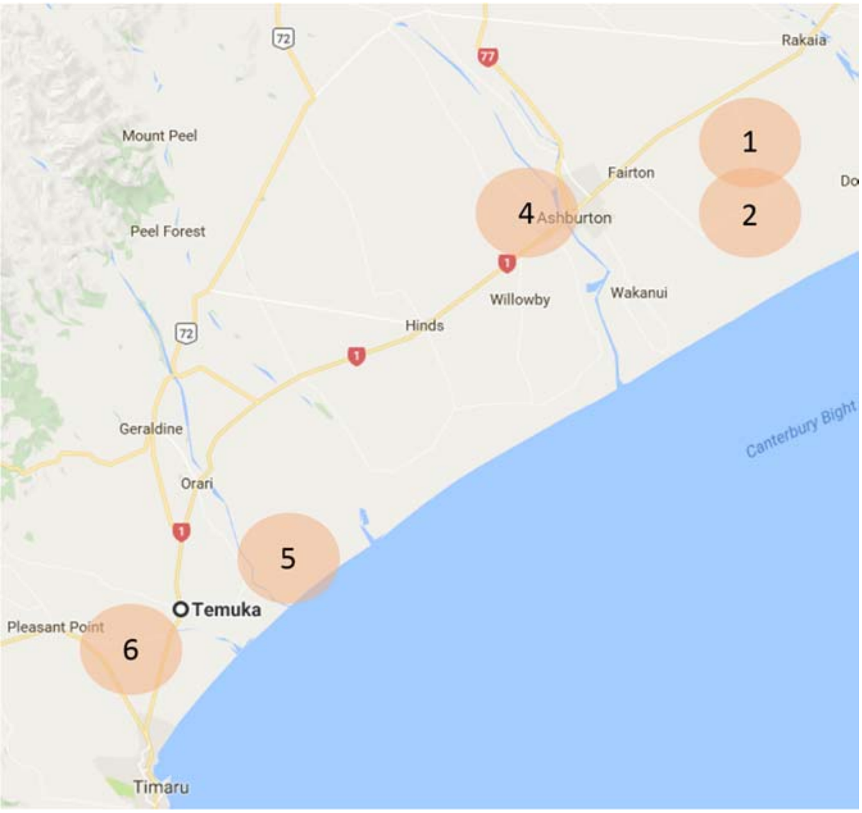

Figure 1. Approximate locations of five trial sites growing ‘Russet Burbank’ potato crops for the 2016–2017 season, near Ashburton and Temuka in Canterbury, New Zealand

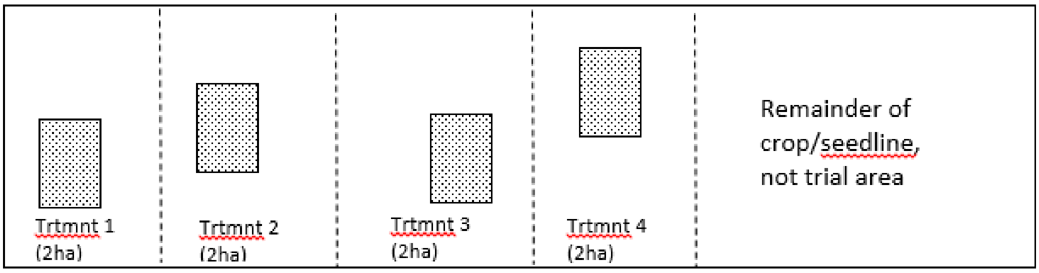

Figure 2. Generalised overview of trial design in each crop: Treatment strips, hand-sampling plots (shaded area) and remaining 'standard' crop under grower tomato potato psyllid (*Bactericera cockerelli*) management practices.

2.2 Insecticide programme

Planting, pre-emergence herbicides, irrigation and crop maintenance were conducted by the grower. The four treatment strips were prescribed the same insecticide programme over the growing season (Table 1). The programme was put together by Roger Blythe (Seed & Field Services Ltd) in collaboration with Dr Jessica Dohmen-Vereijssen from The New Zealand Institute for Plant & Food Research Limited (PFR) according to label rates, number of times a product could be used in a season, good insecticide resistance management and without using organophosphate, neonicotinoid or (synthetic) pyrethroid insecticides.

Table 1. Insecticide programme designed for tomato potato psyllid (*Bactericera cockerelli*) control and prescribed to five 'Russet Burbank' potato crops near Ashburton and Temuka, Canterbury, New Zealand for the 2016–2017 growing season.

Insecticide	IRAC mode of action group number*	Suggested date of insecticide application
Avid®	6	When high pressure early season
Movento™	23	20 December
Movento (+ Avid?)	23	30 December
Benevia®	28	10 January
Benevia	28	20 January
Benevia	28	27 January
Avid	6	3 February
Sparta™	5	10 February
Sparta	5	17 February
Sparta	5	24 February
Sparta	5	3 March
Transform® 0.3	4C	10 March
Transform 0.3	4C	17 March
Transform 0.3	4C	24 March

* Insecticide Resistance Action Committee (IRAC) Mode of Action (MoA) Classification is the basis of MoA labelling of insecticides worldwide.

2.3 Desiccation treatments

After the insecticide programme, which ended on a different date or product for each site depending on crop physiology, weather and natural senescence, the trial included three desiccation treatments and a control (also visualised in Table 2):

- Treatment 1 (Control desiccation): Reglone® plus Methafos twice at 7 day intervals
- Treatment 2: Reglone, then flail followed by Reglone plus Methafos at 7 day intervals
- Treatment 3: Reglone, then flail followed 3 days later by JMS Stylet oil®, followed 3–4 days later by Reglone plus Methafos
- Treatment 4: Reglone, then flail followed 3 days later by JMS Stylet oil, followed 3–4 days later by Reglone.

The individual treatment applications were conducted by the grower using commercial equipment.

Table 2. Calendar-style 8-day plan of desiccation treatments for five 'Russet Burbank' potato crops near Ashburton and Temuka, Canterbury, New Zealand for the 2016–2017 growing season.

Desiccation treatment	Completion of insecticide programme	Days after finishing insecticide programme							
		1	2	3	4	5	6	7	8
Treatment 1 (Control)	Last insecticide	R+M							R+M*
Treatment 2	Last insecticide	R	Flail						R+M
Treatment 3	Last insecticide	R	Flail		JMS Oil				R+M
Treatment 4	Last insecticide	R	Flail		JMS Oil				R

*R = Reglone; R+M = Reglone + Methafos; JMS Oil = JMS Stylet oil

2.4 Tuber sampling

2.4.1 Hand collected samples

At each of five collection dates, 48 tubers were taken by hand from within each hand-sampling plot (50 x 50 m) in each treatment strip. Tuber samples were collected every 2 to 3 weeks from 11 January to 2 March 2017, for a total of four collections throughout the growing season. The fifth collection occurred in the weeks immediately after desiccation and prior to harvest, between 27 March and 10 April. After desiccation, in addition to collecting tubers from the plots within treatment strips, 48 tubers were also collected by hand in an adjacent section of the crop (50 x 50 m) that was not part of the trial (the "remaining 'standard' crop under grower tomato potato psyllid management practices" in Figure 2). This additional post-desiccation sample was to represent tubers in each crop which had been part of the 'standard' crop spray programme growers would typically be directed to use as part of their contracts with potato processors.

For hand-sampling, a randomized pattern of zigzagging was used. A random starting point was selected at the nearest edge of the sampling plot and tubers were collected every two steps forward and two rows over until an edge of the plot was reached then, turning back into the plot, the pattern was repeated until 48 tubers were collected. At each tuber collection point, both gloved hands were placed into the soil at the base of a single plant. The first fully submerged tuber felt was unearthed and collected. When plots were centred over tramlines, tubers were not collected from plants bordering or between the tracks.

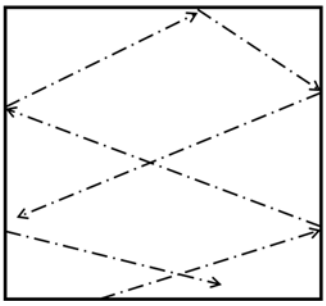

Figure 3. Visualisation of the random sampling pattern used for taking tubers from the hand-sampling plots within a treatment strip.

2.4.2 Truck samples

After commercial harvest, tubers were also sampled from trucks delivering to the McCain Foods' Timaru processing plant. Bucket samples were randomly taken from each truck, while unloading, which had been filled from a single treatment strip in a crop. Two to five full buckets of approximately 15–30 tubers (count dependent on size) were collected from each truck/treatment strip.

2.5 Zebra chip assessment

Hand-collected tubers were placed in storage at 20°C for 4 weeks (to allow for any potential CLso to develop ZC disease in the tuber) and then sliced into crisps, fried and assessed for ZC. An individual tuber contributed one crisp to each fry sample for a total of 48 crisps per treatment per collection date.

A tuber was cut in half, a crisp was sliced from the stolon end using a mandolin and was fried for ZC scoring. Crisps were set on fry trays in groups of 16, photographed pre-fry, fried for 2 min at 190°C in canola oil in the laboratory and photographed post-fry. Raw tuber defects recorded were brown spot, hollow heart, rot and unknown darkening, as well as ZC when flecking showed in raw tubers. A ZC assessment scale of 0–9 was used to score each crisp after frying with 1–4 darkening increasing mostly in the outer ring (vascular bundle) of the crisp and 5–9 darkening increasing throughout the crisp (Anderson et al. 2013; Figure 4).

Tubers sampled from the trucks were tested by the onsite McCain Foods lab in Timaru using their standard pre-processing fry colour assessment protocol. Each tuber from a bucket was stood on end and cut into thick-cut fries with a mechanical cutter. The central fry, essentially a core, was fried and then read at its centre point using a spectrometer. The spectrometer reading was then assigned a corresponding score increasing in darkness from 000–4, according to the

United States Department of Agriculture (USDA) fry colour standard (USDA 1988) (Figure 4), with scores above 2 not acceptable. This is not a test specific for ZC as not all internal discolouration is associated with ZC, e.g. hollow heart also causes internal discolouration.

Similarly, the darkening of the vascular ring can also be caused by drought, potato leaf roll virus or Verticillium wilt, i.e. similar to the 1–4 scores for the hand-sampled tubers. To be able to compare ZC data between the hand-collected tubers and the tuber sampled from the trucks, the decision was made to disregard the 1–4 scores of the 0–9 scale, as no internal discolouration was observed between 1 and 4. Normally in trials conducted by PFR, ZC scores less than 2 on the 0 – 9 scale are acceptable. For these trials, ZC scores of 4 or less were deemed acceptable because of the reasons above.

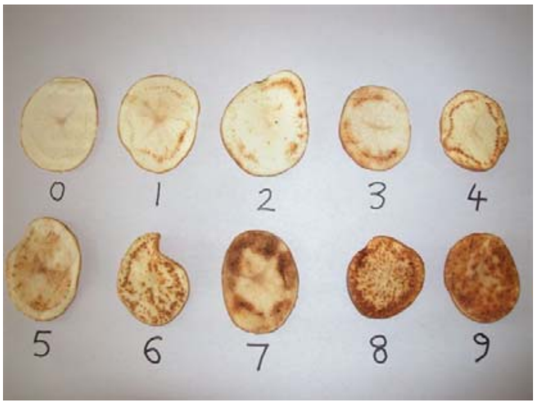

Figure 4. The 0–9 scale used for zebra chip disease assessments of fried crisps in The New Zealand Institute for Plant & Food Research Limited lab in Lincoln (left) and the 000–4 United States Department of Agriculture colour standards for frozen French fried potatoes used in the McCain Foods Ltd process plant in Timaru (right).

2.6 TPP trapping

Large square yellow sticky traps, placed and counted by Fruitfed Supplies, monitored TPP populations in three crops (Sites 4, 5 and 6) throughout the growing season. Traps were placed in each crop along the north, south, east and west boundaries as best possible with considerations to ease of access. TPP were counted from a single trap, the one placed closest to the trial treatment strips.

2.7 Data analysis

Data were plotted and visually explored for trends. Data were unable to be compared by treatments across sites due to deviations from the insecticide programme and desiccation treatments at each site.

3 RESULTS

3.1 Treatment details per site

Complete and detailed spray logs for each site were difficult to elicit from the industry collaborators. Incomplete logs were received for Sites 4, 5 and 6 (Appendix A). For these sites, the insecticide programme was not followed – all three sites disregarded the order of insecticides and Sites 4 and 5 used organophosphates prior to desiccation. No spray logs were received for Sites 1 and 2.

Desiccation treatment applications were not clearly detailed in the brief emailed notes received from the industry collaborators, and it was difficult to determine what actions were made on each day in each treatment (Appendix B). Follow-up requests for clarity received no reply. Hence, the data analysis is restricted to data exploration only.

3.2 Tuber samples

3.2.1 Hand collected samples

The first two hand-collected samples in each crop, taken between 11 January and 1 February 2017, were not included in the data exploration. These young tubers fried too dark to assess for ZC, most likely because of naturally high sugars in the new potatoes.

The percent of acceptable tubers (<5 ZC score on 0–9 scale) showed differences with a range of nearly 20% between treatments within the same site for some visits (for example, Site 6: Visit 3 and 4) and smaller ranges of less than 10% between treatments for other visits (for example, Site 6: Visit 5). Site 4, compared to the other sites, had the smallest range in percent of acceptable tubers between treatments at all visits (Figure 5). Site 4 also had high TPP trap counts compared to the two other sites trapped (Site 5 and 6) during Visits 3 and 4 (Figure 9). However, the potato plants at Site 4 did not look very healthy at our first visit and something else might have affected the plants and/or tubers as well.

Any differences between treatments at each site cannot be explained because we did not receive detailed treatment information for Seed & Field Services.

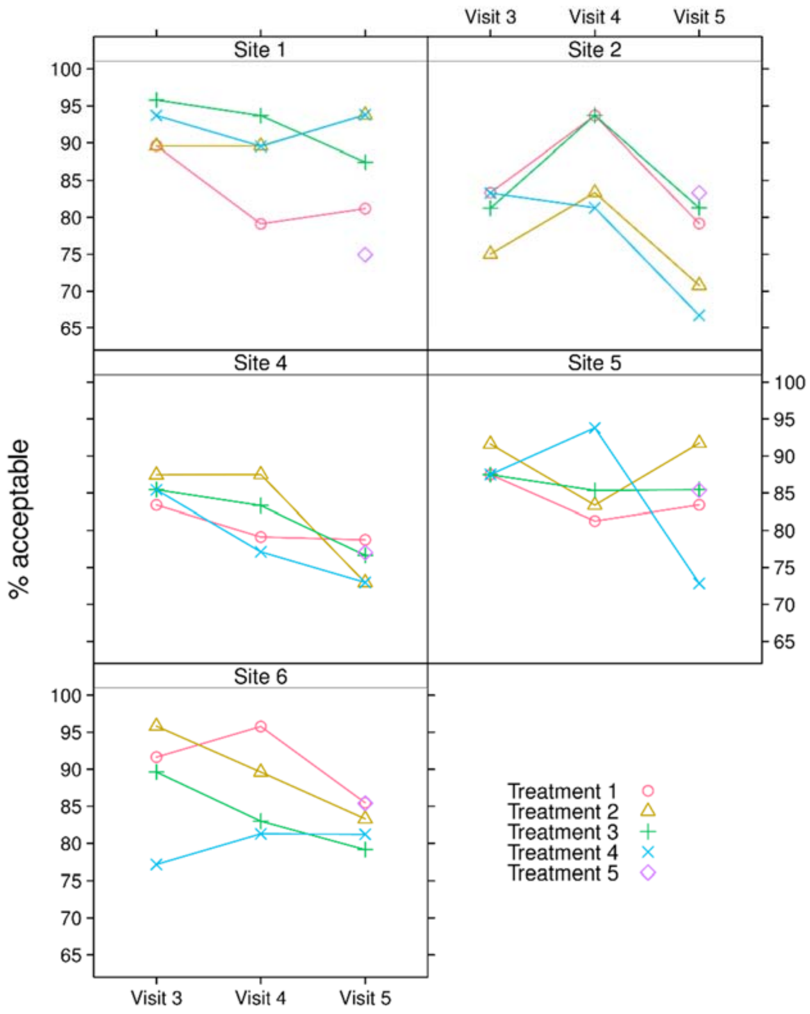

Figure 5. Percent of hand-collected tubers (n=48 per visit per treatment) scored as acceptable in a fry test (zebra chip score <5 on a 0–9 scale) from each visit at the five 'Russet Burbank' potato crops near Ashburton and Temuka, Canterbury, New Zealand for the 2016–2017 growing season. Three tuber collection visits in 2017 are shown: Visit 3 took place between 13 and 17 February; Visit 4 between 17 February and 2 March; and Visit 5 (post-desiccation) between 27 March and 10 April. Treatments 1–4 are desiccation treatments (see Table 2) and treatment 5 (only sampled on Visit 5) is the 'standard' crop sample from an adjacent part of the crop outside of the trial.

Fry patterns of ZC are highly variable and can be difficult to distinguish from other diseases which may cause similar darkening. All fried crisps with putative ZC symptoms were given a ZC score. With the prevalence of internal brown spot and hollow heart in tubers this season there was concern that these defects were contributing to discolouration in fried crisps and inflating ZC scores, both in the lab and at the factory. To review this, raw crisp defects were recorded from photos taken before frying and compared with ZC scores of the same crisp after lab frying (Figure 6).

A B C

Figure 6. Examples of raw tuber defects (A & B) seen in hand-collected samples and the same tray as in B after frying (C) so a comparison between the raw defects and zebra chip scores was possible.

The heat map (Figure 7) did not align high numbers of crisps with raw defects (other than ZC) and ZC scores >4 on the 0–9 scale. Of the recorded raw tuber defects, hollow heart, and particularly internal brown spot, were more likely to align with ZC scores of 3 and lower.

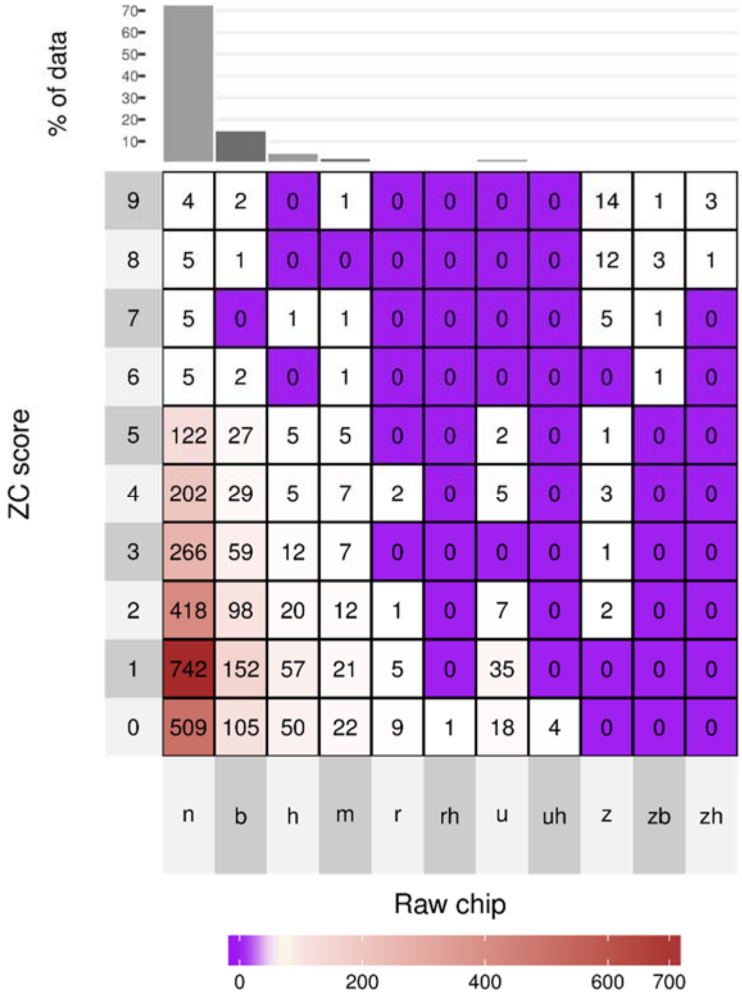

Figure 7. Heat map of raw crisp defects (lowercase letters) and zebra chip (ZC) scores (0–9 scale) of the same crisps after frying, for all tubers collected from hand-sampling plots during Visits 3, 4 and 5 (13 February–10 April 2017). Defects noted in raw chips: n=none, b=brown spot, h=hollow heart, m=missing pre-fry photo (no raw chip comparison); r=rot, u=unknown, z=zebra chip, and combined letters represented combined issues.

3.2.2 Truck tuber samples

Truck samples were collected for Sites 1, 2, 5 and 6. However for Site 2, data for treatments 3 and 4 were not received. Harvest methods had to be altered at Site 4 because of wet field conditions and truck samples could not be collected.

The samples from Site 6 were all over 95% acceptable. The samples in each treatment from Site 2 and Site 5 were at least 90% acceptable. Enough tubers received fry colour scores of 3 or 4 to reduce acceptability in individual samples as low as 85% in Site 2, 78% in Site 5 and 72% in Site 1 (Figure 8).

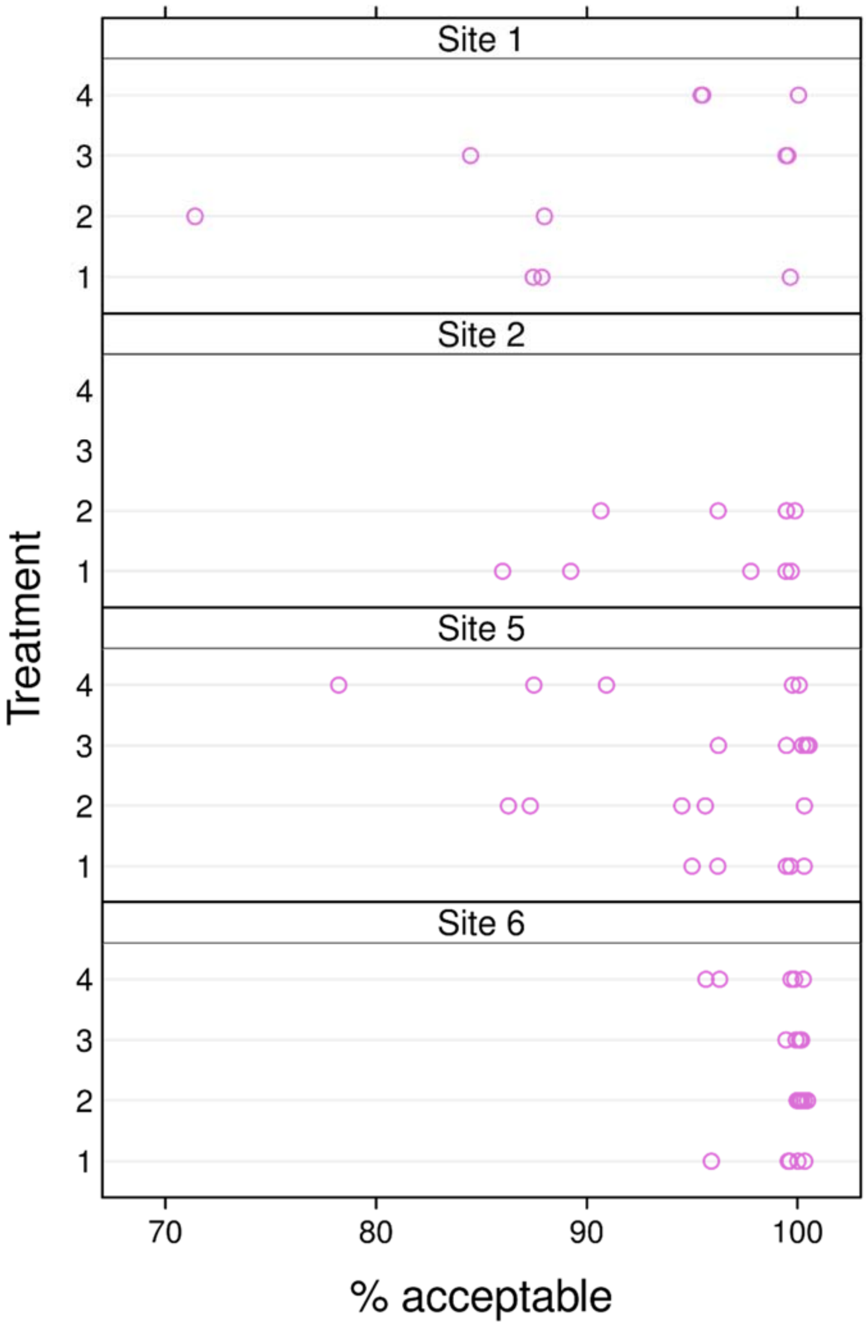

Figure 8. Percent of truck sampled tubers (n=12–25 tubers) scored as acceptable in a fry test (score <3 on United States Department of Agriculture colour standards for frozen French fried potatoes) within each of 2–5 buckets sampled from commercial trucks filled from a single treatment strip at harvest and assessed by the laboratory at McCain Foods Ltd in Timaru. No truck sampled tubers for Site 4 because of wet harvest conditions.

3.3 TPP trapping

TPP trap counts varied greatly among the three sites (Site 4, 5 and 6; Figure 9). Site 4 had TPP trap count peaks two times as high (>20 TPP/week) as the other sites throughout the early-mid season, from 15 December 2016 to 16 February 2017. After this, this site had the lowest weekly average peaks (<5 TPP/week) of the three sites from March to May. Site 5 had peaks over 5 TPP per week throughout most of the season, except in March. Site 6 highest count was near 10 TPP per week on 9 February, followed by just three other dates with slightly lower numbers (5 to 8 TPP per week).

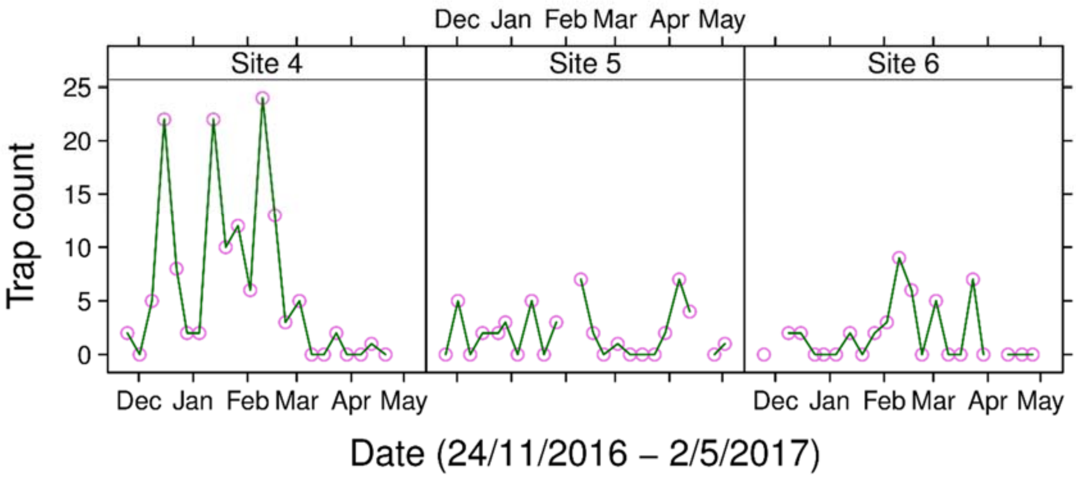

Figure 9. Weekly yellow sticky trap counts of tomato potato psyllid (*Bactericera cockerelli*) from a single trap at each site located on the crop edge closest to treatment strips from 11 November 2016–2 May 2017.

4 DISCUSSION

These trials were designed to review growers' concerns regarding TPP management from mid-February onwards and after desiccation, when there is potential for regrowth. Five trials were conducted at grower properties, which focused on trialling an insecticide programme without organophosphates, neonicotinoids and (synthetic) pyrethroids and on post-desiccation options. Unfortunately, the results could not be put in perspective as incomplete information was received regarding the insecticide programme at each site (what was sprayed and when) and also regarding the post-desiccation treatments (dates and what action was performed).

Generally, the percentage of acceptable tubers decreased over the growing season at each trial site. Grower practice (Treatment 5 in Figure 5) gave the highest percentage acceptable tubers for Sites 2 and 6. However, it is unknown whether the grower had the whole crop under the experimental spray programme or only the trial part.

Working with industry (McCain Foods) brought to light the different approach in assessing discolouration or darkening in potato tubers. The research used slices (crisps), whereas the process plants used an inner, core, French fry. If research for industry focuses on defects related to zebra chip disease, a common goal on how to assess the tubers is preferable.

5 ACKNOWLEDGEMENTS

This study would not have been possible without the growers who volunteered the use of their paddocks and enabled regular access to their potato crops. Scott Clelland (McCain Foods Limited) and Duncan McLeod and Roger Blythe (Seed & Field Services Limited) were key contacts for coordination and liaising with the growers regarding these trials. Rosemary Court (FruitFed Supplies) provided trapping resources and data. This research was funded by levies through Potatoes New Zealand Incorporated.

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USDA 1988. United States Department of Agriculture Color Standards for Frozen French Fried Potatoes. Industry Standard Chart. Baltimore, Maryland, Kollmorgen Corporation.

APPENDIX A

Insecticide programme planned	Insecticide programme at Site 1	Insecticide programme at Site 2	Insecticide programme at Site 4	Insecticide programme at Site 5	Insecticide programme at Site 6
Avid®			Avid		Avid
Movento™			ABBA®	Movento	Movento 150 OD
Movento (+ Avid?)			Movento 150 OD	ABBA	Avid
Benevia®			Benevia	ABBA	Movento 150 OD
Benevia			Movento + ABBA	Movento	ABBA
Benevia			Benevia	Transform	Benevia
Avid			Uphold™	Uphold	Uphold
Sparta™			Tripsol®	Tripsol	Uphold
Sparta			Uphold	Tripsol	Benevia
Sparta			Benevia	Methafos	Begin desiccation (Reglone only)
Sparta			Cobalt™	Begin desiccation (Methafos + Reglone)	
Transform® 0.3			Begin desiccation (Methafos + Reglone®)		
Transform 0.3					
Transform 0.3					

APPENDIX B

	Treatment	Day1 (Products)	Day2 (Action)	Day3	Day4 (Product)	Day5	Day6	Day7	Day8 (Product)	Day9	Day10
Plan	1	Reglone® + Methafos							Reglone + Methafos		
	2	Reglone	Flail						Reglone + Methafos		
	3	Reglone	Flail		JMS Oil®				Reglone + Methafos		
	4	Reglone	Flail		JMS Oil				Reglone		
Grower											
6	1	Reglone	NA[1]	NA	NA	NA	NA	NA	NA	NA	NA
6	2	Reglone	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	3	Reglone	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	4	Reglone	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	1	Reglone + Methafos								?Nothing[2]	
4	2	Reglone + Methafos								? Oil	
4	3	Reglone + Methafos								? Reglone	
4	4	Reglone + Methafos								? Reglone + Methafos	
5	1	Reglone + Methafos				?Flail			?"Follow up chemical treatments"		
5	2	Reglone + Methafos				?Flail			?"Follow up chemical treatments"		
5	3	Reglone + Methafos				?Flail			?"Follow up chemical treatments"		
5	4	Reglone + Methafos				?Flail			?"Follow up chemical treatments"		
1	MISSING										
1	MISSING										
1	MISSING										
1	MISSING										
2	MISSING										

	Treatment	Day1 (Products)	Day2 (Action)	Day3	Day4 (Product)	Day5	Day6	Day7	Day8 (Product)	Day9	Day10
2	MISSING										
2	MISSING										
2	MISSING										

[1] NA = not applicable – after the first reglone no plant showed regrowth.
[2] ? = words preceded by a ? indicate it is unknown whether or when this action or spray was performed.

DISCOVER. INNOVATE. GROW.