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Scoping exercise to evaluate the quality of existing tomato potato psyllid monitoring data and the potential of recently developed models

Dohmen-Vereijssen J, Logan DP, Butler RC, Jorgensen N, Taylor N, Worner SP

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Dohmen-Vereijssen J, Butler RC, Jorgensen N

Plant & Food Research, Lincoln

Logan DP

Plant & Food Research, Te Puke

Taylor N

Plant & Food Research, Hawke's Bay

Worner SP

Bio-Protection Research Centre at Lincoln University, Lincoln

SPTS No. 8042

THE NEW ZEALAND INSTITUTE FOR PLANT & FOOD RESEARCH LIMITED
Private Bag 92 169, Auckland 1142, New Zealand

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This report has been prepared by The New Zealand Institute for Plant & Food Research Limited (Plant & Food Research), which has its Head Office at 120 Mt Albert Rd, Mt Albert, Auckland.

This report has been approved by:

Jessica Dohmen-Vereijssen

Scientist, Vegetable Arable & Southern Entomology

Date: 13 March 2013

Louise Malone

Science Group Leader, Bioprotection

Date: 13 March 2013

Contents

Executive summary

Scoping exercise to evaluate the quality of existing tomato potato psyllid monitoring data and the potential of recently developed models

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The SFF11-058 'IPM tools for psyllid management' project team identified crop monitoring as a way to provide more accurate information on tomato potato psyllid (TPP) numbers directly to growers to assist with their decision making on when to apply insecticide sprays, particularly at the beginning of the season. The milestone project team consisting of Dr David Logan, Nina Jorgensen, Natasha Taylor, Dr Ruth Butler, Ass. Prof. Susan Worner (Lincoln University) and Dr Jessica Dohmen-Vereijssen, met on 28 November 2012 with the aim to undertake a scoping exercise to evaluate the quality of the existing 3 years of TPP monitoring data (SFF09-143, National Monitoring and plant monitoring) to develop or integrate into a prediction model to predict TPP arrival in a crop, population build-up or number of generations in a season or develop thresholds for spraying.

Recommendations for future monitoring using yellow sticky traps:

1. Aim for consistency of trapping methods and protocols over sites and over years.
2. A minimum of four yellow sticky traps per field, but five traps per field would be ideal, with four along the field edge (one on each side of field) and one trap in the middle of the field.
3. Sticky traps to be placed in crops on 1 October each year.
4. Weekly change of sticky traps.
5. TPP numbers on each trap reported.
6. Trapping until 4 weeks after harvest, but if time-constrained, at least until harvest.
7. Access to spray calendars would be very helpful to explain low or high numbers on sticky traps.
8. Unsprayed or organic fields should be included in the monitoring programme every year.
9. Information about the immediate area around the field would be ideal, especially the presence of boxthorn or poroporo. These alternative hosts may explain increased TPP numbers on certain traps. It would be worth exploring phenology of these hosts.

Depending on funding priorities, the existing TPP monitoring data could be used to map TPP abundance and distribution, used in landscape ecology research or more refined CLIMEX model projections.

Recommendations for TPP model improvement:

1. Identify as many biofixes as possible; these could relate to crop and alternative host plant physiology, weather parameters, etc.

2. To improve the model and decreases error margins, research the predictive values of other variables that may have explanatory power, e.g. local measures of dryness and wetness, host plants in the adjacent areas.

3. Life table parameters and resulting Degree Days can be used to predict what might have happened without spraying, a worst-case scenario.

4. To predict TPP numbers later in the season, TPP numbers from the start of the season could be tracked on the bimodal model and from the current date then use the average bimodal to predict future numbers. This is also a worst-case scenario as no other weather parameters than temperature would be included.

5. Review types of phenology models used for other insects.

6. Include monitoring data of unsprayed crops or sentinel plots to refine the model.

7. Forecasting the first arrival of TPP in a crop is currently based on trapping data from eight unsprayed field trials. The data could be refined by analysing existing monitoring datasets from sprayed crops as sprays normally would not have been applied before first arrival. This is probably a more realistic goal than recommendation 4.

The strength of the model at the moment is probably to predict first arrival of TPP in a crop and early season abundance. This is also an important period when TPP control is important and can lead to a reduction in insecticide sprays.

For further information please contact:

Jessica Dohmen-Vereijssen
The New Zealand Institute for Plant & Food Research Ltd
Plant & Food Research Lincoln
Canterbury Agricultural and Science Centre
Private Bag 4704
Christchurch Mail Centre 8140
NEW ZEALAND
Tel: +64-3-325 6400, DDI: +64 3 325 9566
Fax: +64-3-325 2074
Email: Jessica.Dohmen-Vereijssen@plantandfood.co.nz

1 Introduction

The use of crop monitoring and pest thresholds presents an opportunity to provide information to growers with respect to predicting pest insect arrival in their crops, population build-up, number of generations in a growing season, and pest densities in their region. Additionally, it provides growers with tools to better manage the timing and use of agrichemicals and consequently make cost-effective and environmentally sound pest management decisions. The SFF11-058 project team identified crop monitoring as a way to provide more accurate information on tomato potato psyllid (TPP[1]) numbers directly to growers to assist with their decision making on when to apply insecticide sprays, particularly at the beginning of the season.

The milestone project team undertook a scoping exercise to evaluate the quality of the existing TPP monitoring data to develop or integrate into a prediction model for TPP populations or thresholds for timing of spraying. Almost all existing data are collected using yellow sticky traps, which are useful to determine whether the insect pests are at economically important numbers or reach certain thresholds. However, developing prediction models or thresholds becomes complicated when working on a vector/disease system (Jeger et al. 2011) as in the case of TPP and the bacterium-like organism *Candidatus* Liberibacter solanacearum (Lso[2]). The prediction model or thresholds then also depend on the behaviour of the vector, resistance of the plants to vector and disease, disease incidence in the vector population and disease transmission process to the plant and between vectors (Madden et al. 2000; Harrington et al. 2007; Knight & Thackray 2007; Jeger et al. 2009), or even temperature (Murral et al. 1996). A review of disease transmission by TPP is currently being carried out as part of a PFR[3] internally funded project and the knowledge obtained from that project will be very useful for this milestone.

The milestone project team, consisting of Dr David Logan, Nina Jorgensen, Natasha Taylor, Dr Ruth Butler, Ass. Prof. Susan Worner (Lincoln University) and Dr Jessica Dohmen-Vereijssen, met on 28 November 2012 to evaluate the existing monitoring data and discuss the potential of two models recently developed by Luc Tran (PhD student, Lincoln University) (Tran et al. 2012).

Aim

To undertake a scoping exercise to evaluate the quality of the existing 3 years of TPP monitoring data (SFF09-143, National Monitoring and plant monitoring) to develop or integrate into a prediction model to predict TPP arrival in a crop, population build-up or number of generations in a season or develop thresholds for spraying.

[1] Please refer to Section 7 Acronyms & definitions.
[2] Please refer to Section 7 Acronyms & definitions.
[3] Please refer to Section 7 Acronyms & definitions.

2 Current management practices

In New Zealand, current practice is to control TPP in potatoes with insecticides. This is mainly to reduce vector numbers and therefore transmission of Lso, which has severe impacts on its solanaceous hosts. Generally, growers wait until the first TPP arrive in their crop before commencing a spraying programme. This information is mostly obtained by crop monitoring or using yellow sticky traps in fields, both conducted by either commercial companies or industry. When the first TPP have been found, growers will generally start calendar spraying, which results in 2-17 sprays a season, depending on the region and weather conditions. Industry consultants advise growers to monitor their crops for TPP for more sustainable management of the psyllid, e.g. using Integrated Pest Management–compatible insecticides early in the season that have a low impact on naturally occurring TPP predators.

3 Existing monitoring data

3.1 Evaluation of existing monitoring data

In 2009, a 3-year SSF project (SFF09-143) commenced which included the milestone 'National Monitoring of TPP in outdoor crops (tamarillo, potato and tomato)'. TPP numbers were monitored over the season using yellow sticky traps, and in some potato fields, plant assessments were performed (Berry et al. 2011; Dohmen-Vereijssen et al. 2012). Monitoring data were obtained from Plant & Food Research and industry groups. Some of these data have already been used in the development of a forecasting model (see Chapter 4). The team agreed there were two important objectives:

- The number of TPP caught in traps should give a cost-effective indication of adult TPP presence in a crop, and provide a basis for advice on management options for growers.
- Further trapping results are needed to increase sample size and knowledge about psyllid phenology and population dynamics in relation to environmental factors and for further development and refinement of a TPP forecasting model that can be used by industry and growers.

The team agreed that the existing monitoring data are highly variable with respect to:

1. Crop type – tomato, potato and tamarillo.
2. How data were reported – for example, total TPP numbers per 4 traps, per trap or averages.
3. Timing of first yellow sticky trap placement – ranging from October to January.
4. How long sticky traps were left in the field – 1 or 2 weeks.
5. Period of trapping – ranging from 1 month to 6 months.
6. Sticky trap size – some industries / scouts use traps larger than 10 x 25 cm.
7. Number of sticky traps per field – ranging from 1 to 4.

In addition to the variability, almost all monitoring data were collected from insecticide-sprayed fields, reducing their reliability for model development as the data will clearly be altered by insecticide use. Additionally, for the insecticide-sprayed fields, not all spray diaries were available, making it difficult to interpret the monitoring data.

With such variable data, the modellers warn that 3 years of monitoring data at eight sites is not a large enough sample size to build a reliable model. At least 12 site-years of data (e.g. 2 years at 6 sites or 4 years at 3 sites), is required to fully represent local and temporal variability to develop and refine a good model. Luc Tran's initial forecasting model needs additional high quality data for further refinement and reduction of error margins.

3.2 Recommendations

It was decided that consistency of trapping methods and protocols over sites and over years is a priority for model development, preparing management/control guidelines and phenology/population dynamics research.

Further recommendations are:

1. A minimum of four yellow sticky traps per field, but five traps per field would be ideal, with four along the field edge (one on each side of field) and one trap in the middle of the field.

2. Sticky traps to be placed in crops on 1 October each year.

3. Weekly change of sticky traps.

4. TPP numbers on each trap reported.

5. Trapping until 4 weeks after harvest, but if time-constrained, at least until harvest.

6. Access to spray calendars would be very helpful to explain low or high numbers on sticky traps.

7. Unsprayed or organic fields should be included in the monitoring programme every year.

8. Information about the immediate area around the field would be ideal, especially the presence of boxthorn or poroporo. These alternative hosts may explain increased TPP numbers on certain traps. It would be worth exploring phenology of these hosts.

Please note that the team appreciates the effort that goes into monitoring. However, if the monitoring protocol is standardised, the monitoring data becomes more valuable and can be put to better use.

3.3 Other uses for the existing data

- The existing data have been used to map the abundance and distribution of TPP using geographical information systems (Taylor et al. 2012).
- A more detailed landscape ecology study would comprise monitoring data used in conjunction with landscape features (e.g. other crops, presence of alternative host plant and previous crop) to identify TPP hot spots or determine trends in TPP abundance. To achieve that objective, much more information about the fields that were monitored is needed.
- The number of sticky traps needed in a field could be explored by analysing fields that had at least four sticky traps in them. The analysis would involve determining if two traps can predict the numbers on the other remaining traps. This would be a more scientific exercise to look at variability in a field.
- The existing monitoring data (TPP presence only) have been used to develop a first-guess CLIMEX[4] model projection (Vereijssen et al. 2012). Although this model projection needs more work, it has already indicated knowledge gaps and research questions necessary to elucidate TPP phenology and population dynamics in the different growing regions.

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[4] Please refer to Chapter 7 Acronyms & definitions.

4 TPP development parameters & forecasting model

Tran (2012) in his PhD thesis on Population development, phenology, life history parameters and forecasting models of Tomato/potato psyllid (TPP) (Bactericera cockerelli) and the efficiency of a selected natural enemy for its control, reports research relevant to this milestone. His research on the development and population phenology of TPP as indicated by trap catches throughout New Zealand lays the foundation for further development of a forecasting model based on physiological time or degree days (DD[5]) to forecast timing of first psyllid and peak abundance.

Some general comments on TPP model development are:

- There have not been enough seasonal records over sites and years to represent the complexity of the system to fully refine and validate the prototype models. Only 3 years of data from a small set (8) of unsprayed fields were available to develop the models.
- Models need a lot of data over many years or sites to decrease forecast error. Currently, the forecast error is ± 2 weeks on either side of an average date. The question is if growers can work with this error margin.
- There is a need for more monitoring data from unsprayed fields, especially measures of TPP abundance.

What cannot be predicted using the current models?

- TPP abundance cannot be forecast as it is very dependent on weather conditions (rain is known to reduce population sizes), previous population sizes, overwintering, and other factors such as insecticide effects and host quality and availability. Early in the season, population size can more accurately be predicted than later in the season, as the above mentioned factors have not had a large effect on the different psyllid life stages yet.

What can be predicted with the models?

- First arrival of TPP in a crop with a 2-week error margin on either side of the predicted date.
- An estimate of when the next generation is ready to emerge based on current temperature data obtained from a weather station in the area. The estimate will also be subject to error as the effect of rainfall is difficult to measure and incorporate into the model.

Care should be taken predicting first arrival of TPP in a crop. Recent research in Hawke's Bay and Canterbury has shown that all life stages of TPP are present year-round on solanaceous crops (including greenhouse crops), volunteers of these crops, and alternative host plants (Taylor & Berry 2011; Vereijssen & Scott 2013). This research also showed TPP can overwinter on solanaceous host plants and from there could infest crops in spring/early-summer. Clearly, an appropriate biofix[6] needs to be established. Currently, in the absence of detailed data on, for example, crop or alternative host physiology or TPP density on the alternative host that may

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[5] Please refer to Section 7 Acronyms & definitions.
[6] Please refer to Section 7 Acronyms & definitions.

provide a more accurate biofix, DDs are accumulated from 1 July or midwinter, as an alternative.

4.1 Recommendations

1. Identify as many biofixes as possible; these could relate to crop and alternative host plant physiology, weather parameters, etc.

2. To improve the model and decreases error margins, research the predictive values of other variables that may have explanatory power, e.g. local measures of dryness and wetness, host plants in the adjacent areas.

3. Life table parameters (Tran et al. 2012) and resulting DDs can be used to predict what might have happened without spraying, a worst-case scenario.

4. To predict TPP numbers later in the season, TPP numbers from the start of the season could be tracked on the bimodal model and from the current date then use the average bimodal to predict future numbers. This is also a worst-case scenario as no other weather parameters than temperature would be included.

5. Review types of phenology models used for other insects.

6. Include monitoring data of unsprayed crops or sentinel plots to refine the model.

7. Forecasting the first arrival of TPP in a crop is currently based on trapping data from eight unsprayed field trials. The data could be refined by analysing existing monitoring datasets from sprayed crops as sprays normally would not have been applied before first arrival. This is probably a more realistic goal than recommendation 4.

5 Conclusions

5.1 Existing monitoring data

The existing monitoring data obtained in the SFF09-143 National monitoring milestone have been useful to gain insight into population dynamics of TPP in the different potato growing regions of New Zealand. We conclude that the data lack consistency between years and regions and are therefore unreliable for use in a definitive model. A more organised, unified approach with clear guidelines around TPP monitoring would greatly benefit industry and research. Depending on funding priorities, the existing data could be used to map TPP abundance and distribution, used in landscape ecology research or more refined CLIMEX model projections.

5.2 TPP development parameters & forecasting model

The development study (Tran et al. 2012) has established parameters that have resulted in DD for each life stage of TPP and an overall egg to adult DD to be calculated. This information allows predictions of first arrival of TPP in a crop based on DD from 1 July. However, all life stages of TPP have been shown to be present year-round in Hawke's Bay and Canterbury, overwintering on solanaceous alternative host plants. The biofix for the model needs to be further refined and may include alternative host plant physiology. The current forecasting model is based on 3 years of monitoring data in eight fields. To refine the model and reduce forecasting errors, more monitoring data over several years is required. Additionally, further analyses of the existing monitoring data in relation to other environmental variables to further refine the model should be carried out. The strength of the model at the moment is probably to predict first arrival of TPP in a crop and early season abundance. This is also an important period when TPP control is important and can lead to a reduction in insecticide sprays.

6 Acknowledgments

We would like to thank industry and scouts that freely shared their trapping data with Plant & Food Research; these data have been very helpful to gain insight into the psyllid problem in New Zealand. Funding for this scoping exercise was obtained from the Sustainable Farming Fund (SFF11-058).

7 Acronyms & definitions

Biofix	The date to begin accumulating degree-days, known as the biofix date, varies with the species. Biofix dates are usually based on specific biological events such as planting dates, first trap catch, or first occurrence of a pest.
CLIMEX	A CLIMEX model describes the response of a species or other taxonomic unit to climate, either to the long-term average climates of different locations or to climates in different years at the same place. CLIMEX enables the assessment of the risk of a pest establishing in a new location and the potential success or failure of a biological control agent with no knowledge of the species, except for knowing the current locations where they occur.
DD	Degree Day; the total amount of heat required, between the lower and upper development thresholds, for an organism to develop from one point to another in its life cycle; this is calculated in units called degree-days (°D).
Lso	The bacterium-like organism *Candidatus* Liberibacter solanacearum that can be transmitted to a plant by the tomato potato psyllid.
PFR	Plant & Food Research.
TPP	Tomato potato psyllid (*Bactericera cockerelli*).

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