

The tomato-potato psyllid lifecycle on three traditional Maori food sources

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Abstract

Three traditional Maori food sources, namely taewa (Maori potato, *Solanum tuberosum* ssp. *andigena* and ssp. *tuberosum*), kumara (sweetpotato, *Ipomoea batatas*) and poroporo (*Solanum aviculare* syn. *S. laciniatum*), are known hosts of the tomato/potato psyllid (TPP or *Bactericera cockerelli*) in New Zealand. Potentially these host plants may serve as bridging hosts or harbour the bacterial disease agent *Candidatus Liberibacter solanacearum* syn. *psyllaourous*, the causal agent of the lethal plant disease Zebra Chip (*Liberibacter*). This study assessed the relative ability of these three crops to host TPP in New Zealand. The results indicated that taewa (total lifecycle 27.5 days) was the most suitable host species, followed by poroporo (total lifecycle = 30 days) and finally kumara (total lifecycle = 39 days). This study showed that TPP completed their lifecycle on all three hosts which warrants their (host plants) management with a view to minimise the proliferation of TPP across seasons.

Additional keywords: *Candidatus Liberibacter solanacearum* syn. *psyllaourous*, taewa, kumara, poroporo

Introduction

The tomato-potato psyllid (TPP or *Bactericera cockerelli* (Sulc)) was first discovered in Auckland, New Zealand in 2006 (Teulon *et al.*, 2009). Native to North America, it is thought TPP arrived in New Zealand via Hawaii (Tomatoes New Zealand, 2009). TPP feed by piercing plant tissues and sucking the contents of the phloem; host plants may appear weakened in response to high population infestations and reduced yields may eventuate. TPP is implicated in vectoring (or transmitting) the pathogen *Candidatus Liberibacter solanacearum* syn. *psyllaourous*, the causal agent of Zebra Chip (ZC or *Liberibacter*) disease. Symptoms associated with *Liberibacter* include; top yellowing, plant

death, leaf scorching, reduced fruit/tuber yield and pigmentation in potato tubers. Successive annual population outbreaks coupled with widespread *Liberibacter* infection continue to challenge New Zealand's horticulture sector. It is estimated that since the arrival of this pest damage resulting from TPP infestation and *Liberibacter* has cost the New Zealand potato industry alone over NZ\$60 million as at 2010 (Potatoes New Zealand, 2010).

Taewa (Maori potato, *Solanum tuberosum* L. ssp. *andigena* Hawkes and ssp. *tuberosum*), kumara (sweetpotato, *Ipomoea batatas* (L.) Lam) and poroporo (*Solanum aviculare* G. Forst. syn. *S. laciniatum* Ait.) are hosts of the TPP in New Zealand (Potatoes New Zealand,

2009) and potentially susceptible to feeding damage and disease transmission. Growers utilising traditional (indigenous) Maori growing practices face challenges such as adopting chemical sprays to control TPP and low yields which translate into reduced economic gains. TPP and *Liberibacter* disease have already had a devastating effect on smaller commercial taewa growing units such as marae gardens in the North Island, with crop losses of up to 90%, culminating in the inability to supply taewa for cultural use, economic gain or as carry over seed tubers for future seasons.

This study assessed the TPP lifecycle on three traditional Maori food sources: taewa, kumara and poroporo. The project aimed to produce information relevant to a national context but with a focus on traditional Maori food sources.

Materials and Methods

Colony rearing

TPP for these experiments were originally collected from a number of host plants (tomatoes, potatoes and capsicum) in the Whanganui district then reared on tomato plants (*S. lycopersicum* L. var. *lycopersicum* syn. *Lycopersicon*

esculentum Mill. cv. 'Moneymaker'). Five rearing plants were established and maintained within net cloches (mesh size 1.35 mm²) in a glasshouse environment. TPP were sourced as required and host plants were replaced when they became unhealthy.

Lifecycle assessment

All three host species; taewa, kumara and poroporo were assessed as hosts of the TPP in a closed environment (glasshouse) in Palmerston North. The length of the pre-oviposition period, egg incubation and nymph development was measured for each of the three host plant species.

Temperature and light regimes were not controlled in this study but daily high and low temperatures were recorded (Figure 1). TPP development and survival occurs at temperatures between 15.5°C and 32.2°C and the development threshold is 7°C (Biosecurity, 2009). The temperature range throughout the monitoring period was 8-31°C, within the functional range of the TPP and marginally above the development threshold limit. At two points of this study the temperature reached or exceeded 30°C, but exposure to these temperatures was not prolonged.

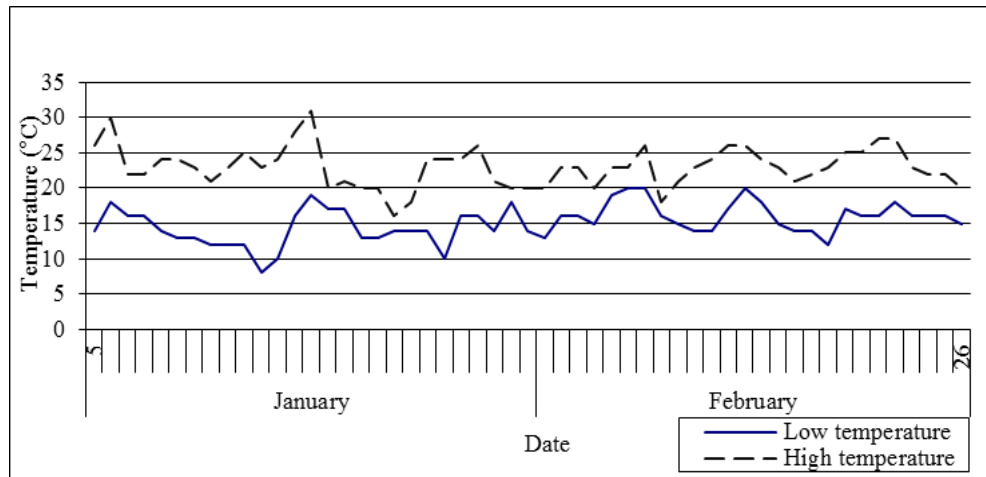


Figure 1: Daily glasshouse temperature (°C) recorded throughout the closed environment monitoring period (January 5 to February 26 2011).

Sampling was undertaken in January and February 2011. The *moemoe* variety of taewa was used in this study due to the availability of seed tubers and its popularity with growers and shoots (tipu) of the *Owairaka* kumara variety purchased from a commercial nursery (Oderings Nursery, Palmerston North). Immature poroporo plants were uplifted from a single site on Massey Hill (Palmerston North) and potted for this study.

Sample lines consisting of five plants per host species were infested with one pair of known age (F1) adult TPP (one male, one female) and covered with net cloches. The sample lines were then monitored daily for the first oviposition (F2) event. The time period between the appearance of F1 adults and F2 eggs was considered the pre-oviposition period (Abdullah, 2008). Two sample units of 10 eggs each were allowed to remain on each plant (Abdullah, 2008), the remainder (if any) were brushed off with a paintbrush. The adult TPP pair was removed 24 hours after this initial egg lay event. A total of 100 eggs per host plant species were monitored throughout the study. Areas containing these sample units

were marked (string tied to particular leaflet) to enable location during monitoring. Egg incubation was measured from the first oviposition event until the emergence of nymphs. Nymph development was the period from the end of the egg incubation period to the emergence of the first adults. Egg and nymph survivorship was also recorded. Each lifecycle parameter was measured in days (24 hour periods) lapsing at 8.30am when the trial replicates were monitored daily. Survivorship was also recorded for eggs and nymphs; assessments were made on the basis of the number individuals surviving through to the next lifestage (e.g. egg survival was measured as the number of individual eggs surviving through to the first nymphal stage).

Contained leaf samples

Ten contained leaf samples of each host plant species allowed the assessment of female fecundity, pre-oviposition period, adult longevity and survival in relation to host species.

Clear one litre plastic containers used within this trial were modified; a portion of

the upper surface (top or lid) was cut out and replaced by mesh (1.35mm²) cloth to allow air flow and a small toothed crimp clip attached on one side of the container to hold each sample leaf (Abdullah, 2008). Adult TPP were carefully released into these containers via the mesh opening. Fresh leaves were placed into modified plastic containers daily and old leaves removed and assessed for egg numbers under a dissecting microscope (Abdullah, 2008; Yang and Liu, 2009). Each container was inoculated with one pair (one male, one female) of TPP adults and observed daily. This trial was run in the glasshouse alongside the lifecycle assessment.

The pre-mating period was recorded from the time of collection (as newly emerged adults) until mating was observed (Abdullah, 2008). Adult longevity was measured from the time of emergence until death. Egg numbers over the oviposition period were recorded to assess female fecundity. Oviposition period was measured from the laying of the first egg to the last egg laying event or in some cases when the female TPP died.

Data analysis

All data was entered into Microsoft Excel and used in conjunction with Minitab to generate graphical displays, basic statistics (mean and standard error) and statistical tests (F tests and Fisher's LSD) regarding population growth.

For the lifecycle data, mean values were generated for each of the recorded variables (life stage length, fecundity and survival) over the ten sample units (5 plants x 2 sample units per plant) for each host plant species; also the standard error for these values were calculated using Minitab. F-tests and Fisher LSD tests were undertaken to determine any significant relationships in

terms of lifecycle parameters for the three host plant species. The same process was carried out for the contained leaf sample data: average egg counts and standard error were calculated over the ten replicates. ANOVA tests (F-test and Fisher's LSD) were then undertaken to show any significant differences between oviposition behaviour in terms of the three host species.

Total development and lifecycle calculations

Total development time was calculated by adding the egg incubation period and nymph development together. Total lifecycle length was calculated by adding total development time and pre-oviposition period (Abdullah, 2008).

Results

Under these experimental conditions the pre-oviposition and nymph development period are similar across the three hosts. The egg incubation period was significantly longer on kumara compared to the other two host species. The results showed that TPP development (total development and total lifecycle) was shortest on taewa, followed by poroporo and finally kumara (Table 1). Egg and nymph survivorship differed significantly between the three host species. The same trend was seen for both of these parameters i.e. taewa > poroporo > kumara (Table 2).

The data collected from the contained leaf samples (Table 3) showed the same relationship as survivorship (Table 2); notably the pre-mating period was significantly shorter on taewa than poroporo and kumara and three times more eggs were laid on taewa compared to kumara.

Adult longevity, both male and female and oviposition period were significantly shorter on kumara (Table 3).

Table 1: Lifecycle parameters of *B. cockerelli* fed either on taewa, poroporo or kumara under glasshouse conditions

Development time (days)						
Stage	Taewa	Poroporo	Kumara	LSD _(0.05)	F _(2,27)	P
Pre-oviposition	7.1	8.2	8.7	2.064	1.32	0.283
Egg incubation	5.9	6.8	11.3	2.347	12.8	<0.001
Nymph development	14.5	15.8	19.0	-	2.95	0.069
Total development ¹	20.4	22.6	30.3	5.996	6.33	0.006
Total lifecycle ¹	27.5	30.0	39.0	7.583	5.13	0.013

¹Equations: Total development period = Incubation period + Nymph development (Abdullah, 2008), Total lifecycle = Total development period + pre-oviposition period (Abdullah, 2008).

Table 2: Survival of *B.cockerelli* egg and nymphal life stages fed either on taewa, poroporo or kumara under glasshouse conditions

Survivorship (number of eggs or nymphs)						
Stage	Taewa	Poroporo	Kumara	LSD _(0.05)	F _(2,27)	P
Egg	9.7	7.9	2.6	1.29	68.88	<0.001
Nymph	8.6	5.8	1.6	1.326	59.43	<0.001

Table 3: Female reproductive parameters and longevity of *B. cockerelli* adults fed on taewa, poroporo or kumara under glasshouse conditions

Development time (days)						
Stage	Taewa	Poroporo	Kumara	LSD _(0.05)	F _(2,27)	P
Pre-mating	5.9	7.7	8.0	1.074	9.41	0.001
Fecundity	180.1	139.7	54.4	34.66	28.87	<0.001
Oviposition period	20.4	20.7	16.5	3.124	4.74	0.017
Male	20.0	17	14.2	3.819	4.86	0.016
Female	27.8	26.4	21.6	4.552	4.3	0.024

Discussion

Poroporo and kumara are recognised hosts of the TPP in New Zealand (Potatoes New Zealand, 2008) however little is known about the relationship between the TPP and these two host plants. Martin (2008) demonstrated that TPP could survive and complete their lifecycle on these two host species and concluded that there was a good association between insect and host species.

Yang and Liu (2009) demonstrated that TPP “survival, development and reproductive rates” vary in response to host

plant species. This study supports their findings. Table 1 shows that development time for the pre-oviposition, egg incubation and nymph development periods was similar across the hosts plant species, only the egg incubation period was significantly longer on kumara. This coupled with increased reproductive potential (significantly shorter pre-mating period and higher female fecundity) makes taewa a more suitable host for the TPP in terms of survival and fecundity. The oviposition period was significantly shorter on kumara. Based on these results taewa and poroporo

would therefore be more prone to excessive population outbreaks.

TPP performance on poroporo was intermediary of the three host species assessed within this study. TPP development (egg to adult, total development and total lifecycle), adult longevity and oviposition period were similar on taewa and poroporo, showing that TPP performed relatively well on the host. Female fecundity and survivorship (egg and nymph) were significantly lower on poroporo when compared with taewa showing that poroporo is relatively susceptible to TPP. Further research is required in regards to the seasonality of TPP infestation on poroporo and the possibility of *Liberibacter* infection to provide growers with a complete overview of the relationship between TPP and poroporo.

The data collected shows that kumara (*Convolvulaceae*) was the poorest host of the TPP. Longer egg incubation period coupled with lower survival and female fecundity indicates that kumara was the least suitable host of the TPP in this study. However it was confirmed that TPP are capable of completing their lifecycle on the host. This study supports the claim that kumara is a 'poor' host of the TPP (Biosecurity NZ, 2009).

This study has demonstrated that TPP are capable of completing their lifecycle on each of the three hosts assessed. Due to the significance of taewa in the annual lifecycle of the TPP in New Zealand, pest management strategies should be employed before planting and throughout the entirety of the cropping season. Volunteer potatoes growing out of season should be removed to minimise the risk of bridging hosts for TPP and *Liberibacter*. As an 'intermediate' host of the TPP, poroporo too may require

removal or chemical spraying especially during the summer cropping season. Damage or disease symptoms have not been recorded on poroporo or kumara but it is suggested that growers monitor these host plants and manage TPP populations as a precaution.

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