The Effects of ENTRUST® (Spinosad) on Reproduction and Feeding Activity of *Epitrix tuberis* (Coleoptera: Chrysomelidae) in Potato

Report to:
Organic Sector Development Program, Lower Mainland Horticultural Improvement Association, Potato Industry Development Committee, and Fraserland Organics

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Executive Summary

Larval tunneling by the tuber flea beetle, *Epitrix tuberis* Gentner, is a major cause of tuber damage, and reduced marketability, of potatoes on the west coast of British Columbia. ENTRUST®, an OMRI-listed formulation of spinosad, poses a possible option for organic flea beetle management. Field trials in 2006 revealed significantly less larval feeding damage on tubers collected from ENTRUST® plots than untreated. In 2007 a follow-up study was conducted to examine application of ENTRUST® based on economic thresholds, and its impact on later generation adults and feeding damage on harvestable tubers.

Three treatment regimes were established in two organic potato fields on the first appearance of second-generation tuber flea beetle adults: 1 ENTRUST® application, 2 ENTRUST® applications, or no spray. Adult tuber flea beetles were monitored weekly using sweep net samples. Tuber damage was measured at harvest by calculating the % of tuber weight discarded due to tuber flea beetle damage.

No significant differences were seen between adult counts in ENTRUST®-treated or untreated plots in either field. Although 2005 and 2006 trials indicated reduced tuber damage with ENTRUST®, tuber damage levels in 2007 trials were also similar for all treatments. A critical difference in methodology between seasons is that tuber flea beetles were introduced the day of application in 2005 and 2006, while they emerged and migrated freely in plots over an extended period of time in 2007. The short residual efficacy of spinosad, and the need for contact with or ingestion of the chemical are indicated as possible explanations for apparent failure. It is inferred that targeting the two seasonal ENTRUST® sprays at first generation tuber flea beetles will improve damage control.

INTRODUCTION

The tuber flea beetle, *Epitrix tuberis* Gentner, is considered a major pest of potatoes in British Columbia (Neilson et al., 1953). Larval feeding damages tubers and results in reduced marketability (Giles, 1987; Vernon & Mackenzie, 1991). Adult tuber flea beetles (TFB) also cause characteristic feeding damage on potato plant foliage resulting in a “shotholed” appearance (Vernon *et al.*, 1990).

Spinosad formulations are a possible option for organic TFB management, as they are very effective against foliar chewing insects. An advantage of spinosad treatments is that they are relatively harmless to natural enemies. Small-scale field trials in 2006 revealed significantly fewer larval feeding tunnels on tubers collected from ENTRUST® (the organic formulation of spinosad) plots than from untreated Control plots (Chu et al, 2006).

Reduction in feeding damage in ENTRUST® plots was hypothesized to be an indirect indication of higher mortality of the adult TFBs originally added to plots. The study recommended that further work continue to examine application of ENTRUST® based on economic thresholds of 1 TFB per 60 plants for emerging over wintering generation beetles or 1 TFB per 40 plants sampled for subsequent generation beetles, and its impact on later generation adults and feeding damage on harvestable tubers.

The purpose of this study was to determine efficacy of ENTRUST® (the organic formulation of spinosad) as a potential organic approach for reducing TFB damage on potatoes. ENTRUST® application was paired with intensive crop monitoring throughout the season.

MATERIALS AND METHODS

Establishment

Plots were established on two organic potato fields: Field 1 was located in West Delta and the potato variety grown was Redsen; Field 2 was located on Westham Island and Kennebec was the variety being produced. Plots for the trial were laid out at the first appearance of second-generation TFB adults. In Field 1, plots were 15m long x 8 rows wide in the West headland, and 14 rows wide on the North edge. In Field 2, plots were 20m long x 20 rows wide, and located in the row ends on the North and East edges. In both fields 5-m long buffers separated plots. A summary map detailing plot lay-out and other field details is summarized in Appendix 1.

Three treatments were replicated six times on Field 2: 1 x ENTRUST®, 2 x ENTRUST®, and untreated controls. Six replications of the 2 x ENTRUST® and control treatments only were applied on Field 1 due to limited space.

Treatment

ENTRUST® treatments were applied to second-generation adults when populations exceeded the second-generation economic threshold of 1 adult per sample of 40 plants (**Table 1**). A maximum of two applications were applied as per label recommendations.

Treatments were applied to Field 1 by Bow Chong farms, using a tractor-pulled boom sprayer that covered 14 rows. Treatments were applied to Field 2 by Dhaliwal farms, using a 20-row sprayer. ENTRUST® was applied at a rate of 40g per acre in both fields

Table 1: Treatment dates.

Field	**Treatment**	**1st Spray**	**2nd Spray**
Field 1	2 x ENTRUST®	Aug 3 2007	Aug 10 2007
Field 1	Control	-	-
Field 2	1 x ENTRUST®	July 27 2007	-
Field 2	2 x ENTRUST®	July 27 2007	Aug 3 2007
Field 2	Control	-	-

Adult Monitoring

Adult tuber flea beetles (**Fig 1**) were monitored weekly, using protocol described in the BC potato grower IPM guide (Syrovy and Meberg, 2006). Sweep net samples, consisting of twelve sweeps knocking four plants with each sweep, were taken from the middle 4 rows of each plot. TFB adults were counted and recorded. A single pre-treatment count was made in each plot one week prior to treatment. Following treatment counts were taken until potatoes were top-killed.


Figure 1 (left): Adult tuber flea beetle (*Photo: J. W. Chu*).

Figure 2 (right): Sub-surface tunneling by tuber flea beetle larvae (*Photo: L. Syrovy*).

Damage Assessment

Five plants were hand-dug from the centre rows of each plot, at least 1 week after top-kill. Ten potatoes were selected from each plot, in an average size range representative of the field. Effort was made to keep tuber sizes between 5 and 12 ounces (Canada No 1 for round potatoes), however some were underweight at Jackson's.

Tuber damage was assessed using a cutaway method described in CFIA grading protocol (Anon., 1999). Peeled tuber start weights were recorded, before larval feeding tunnels (**Fig 2**) were removed using a series of straight cuts approximately ¼ inch thick. Cut portions were weighed, and percentages of start weights calculated. Tubers were classed as Canada No 1 or Canada No 2 as follows: Canada No 1 = less than 5% of total tuber weight must be cut away to remove the damage or defect; Canada No 2 = less than 10% of total tuber weight must be cut away to remove the damage or defect (Anon., 1999). Canada No 1's, Canada No 2's, and culls were summed for each plot to obtain a frequency out of ten.

Statistical Analysis

Weekly adult counts were analyzed using repeated measures MANOVA. A one-way analysis of variance test was used to analyze the feeding damage dataset. The number of Canada No. 1 grade tubers was compared using one-way ANOVA (Field trim) or Students' t-test (Field Jackson). All statistical analysis was done using JMPIN® version 4.0.3 (SAS Institute Inc, 2000).

RESULTS

In most plots at Jackson's, tuber flea beetle adult levels remained above the economic threshold of 1 adult per sample of 40 plants for the duration of the trial. On average, 1-7 adults were seen per plot. Overall tuber flea beetle populations did not change significantly over the sampling period. Adult counts were not significantly different in ENTRUST®-treated versus control, nor was there a significant treatment x time interaction.While slightly lower levels of adult TFB were observed in ENTRUST®-treated plots (**Fig 3**), these treatment differences were not significantly different (**Table 2**). Similarly, tuber damage levels were not significantly different for untreated controls or plants treated with ENTRUST®. Although no significant treatment effect was seen with the number of Canada No 1's, as with adult counts, there was a trend towards more Canada No 1's in Entrust-treated plots (**Fig 4**) but again treatment differences were not significant (**Table 2**).

Higher adult TFB populations were seen at Trim than at Jackson's. On average, 5-14 adults were seen per plot until the last week of sampling. Contrary to trends at Jackson's, overall adult TFB populations at Trim changed significantly over time; however, no significant differences were observed between. As with adult counts, there was no significant treatment effect on tuber damage (**Fig 6**).

Table 2: Summary of statistical results for Fields 1 and 2

	Weekly TFB adult count	Number of Canada No. 1 Grade tubers
Field 1	Treatment: $F_{1,10}$ = 0.97; P = 0.35 Time: $F_{2,9}$ = 1.76; P = 0.23 Treatment X Time: Wilks' λ:; $F_{2,9}$ = 1.83; P = 0.21	Treatment: $F_{1,10}$ =2.95; P= 0.12
Field 2	Treatment: $F_{2,15}$ = 0.05; P = 0.95 Time: $F_{4,12}$ = 5.83; P = 0.008 Treatment X Time: Wilks' λ:; $F_{8,24}$ = 0.73; P = 0.66	Treatment: $F_{2,15}$ = 1.81; P = 0.2

DISCUSSION

Despite the failure of ENTRUST® to control tuber flea beetle adults and damage in these trials, two years of small field trials by E. S. Cropconsult have indicated that treating potato foliage with ENTRUST®, resulted in a reduction in the adult TFB population which subsequently lead to less larval feeding damage on tubers (O'Grady and Meberg, 2005; Chu et al, 2007); this effect was significant in 2006 trials (Chu et al, 2007). In addition, ENTRUST® has been demonstrated toxic to the eggplant flea beetle *Epitrix fuscula* (McLeod et al, 2002), and is labelled for suppression of the crucifer flea beetle in Canada.

One possible explanation for the results seen in this trial is the residual efficacy of spinosad. In studies with spinosad on eggplant flea beetle, mortality of beetles placed on treated foliage dropped to 65% one day after treatment, and continued to decline to 6.3% after 6 days (McLeod et al, 2002), indicating that activity of the chemical had degraded within one week. In studies where tuber flea beetles were released into plots at various intervals before or after insecticide sprays, BC authors found that residual control generally varied from 4 to 7 days, depending on the chemical (Vernon and Mackenzie, 1991). Vernon and Mackenzie (1991) suggest that a ten-day interval between sprays may not give adequate TFB control, despite good knockdown activity (Vernon and Mackenzie, 1991).

E. S. Cropconsult trials in 2005 and 2006 demonstrated initial knockdown activity of ENTRUST® on tuber flea beetles, as beetles were released into plots the same day as plants were treated. However, in the 2007 study, TFB populations remained above threshold in ENTRUST® plots after the label maximum of two sprays per season was reached, and did not change significantly compared with untreated plots. The difference between these trials is that in 2007, tuber flea beetles indigenous to the field emerged and migrated freely into plots. Since ten days of egg laying by TFB can result in twenty days of emergence for the next generation (Vernon and Mackenzie, 1991), and given the short residual activity of spinosad, perhaps the lack of control is not surprising.

A second explanation for the results is the mode of action of spinosad. Although there is some evidence of systemic activity when spinosad is applied to rock wool (van Leeuwen et al, 2005), most work suggests that spinosad works primarily by direct contact and ingestion of the chemical (Thompson et al, 1999). Necessity of direct contact and ingestion would suggest that thorough coverage is essential to get good knockdown.

These two explanations, the residual efficacy and the mode of action of spinosad, both suggest that more careful timing may allow better control of TFB adults and tuber damage with ENTRUST®. Carefully timed insecticide sprays based on visual sampling, along with field rotation, form the basis of the IPM programme used to control tuber flea beetles for nearly twenty years in the Fraser Valley. In rotated fields, very low populations of first-generation adults concentrate in field headlands, and can be controlled with 1 or 2 well-timed edge sprays (Syrovy and Meberg, 2006). Prior to the current programme, growers targeted second-generation adults, which numbered approximately 200 times the first generation. This method resulted in an average of 6 full field sprays in a season (Kabaluk and Vernon, 2000). Since ENTRUST® is only labelled for a maximum of two applications in a season, timing would seem essential with this product. An added benefit of targeting first generation TFB is that the plants are smaller at this stage and the plant surface area in contact with ENTRUST® will be greater.

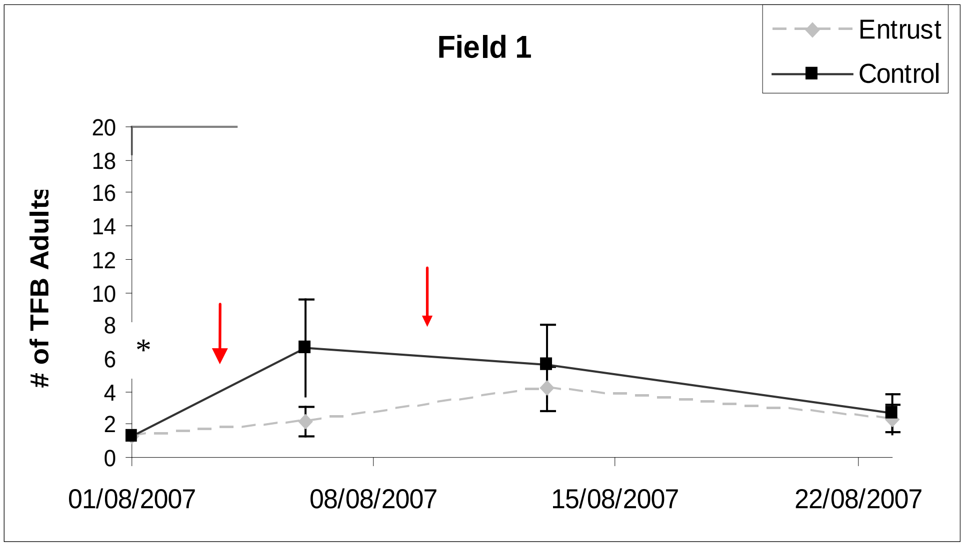

Figure 3: Weekly catches of adult tuber flea beetles at Field 1, in plots treated with Entrust vs. untreated controls. Bars represent standard error means for averages. Red arrows indicate spray dates in Entrust plots.

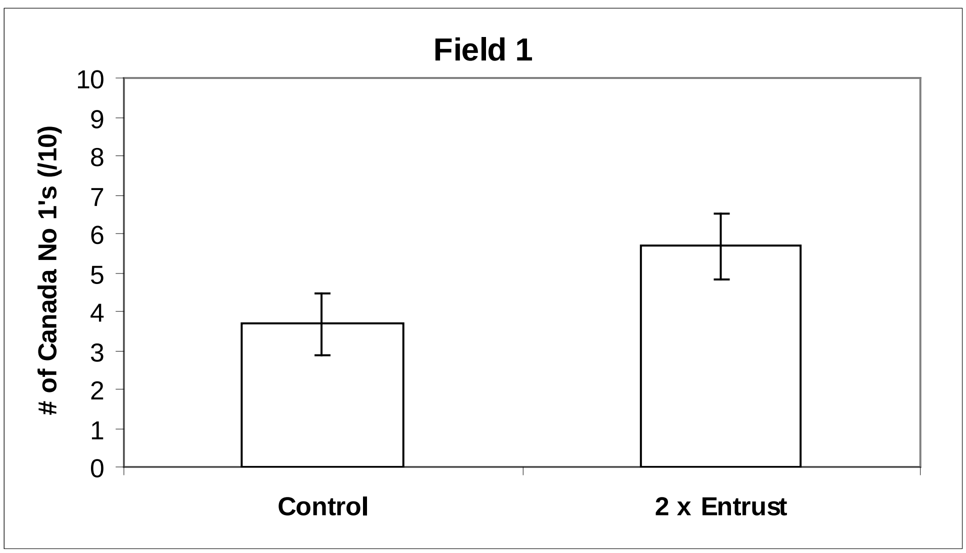

Figure 4: Effect of Entrust treatment, for tuber flea beetle control in Field 2, on the number of Canada No 1. grade tubers (i.e. < 5% of tuber weight with damage or defect) harvested from plots. Control treatment involved no insecticide applications for tuber flea beetle control. Bar represent the mean (± s.e.) number of potatoes out of 10 assessed from each plot. N=6 for each treatment.

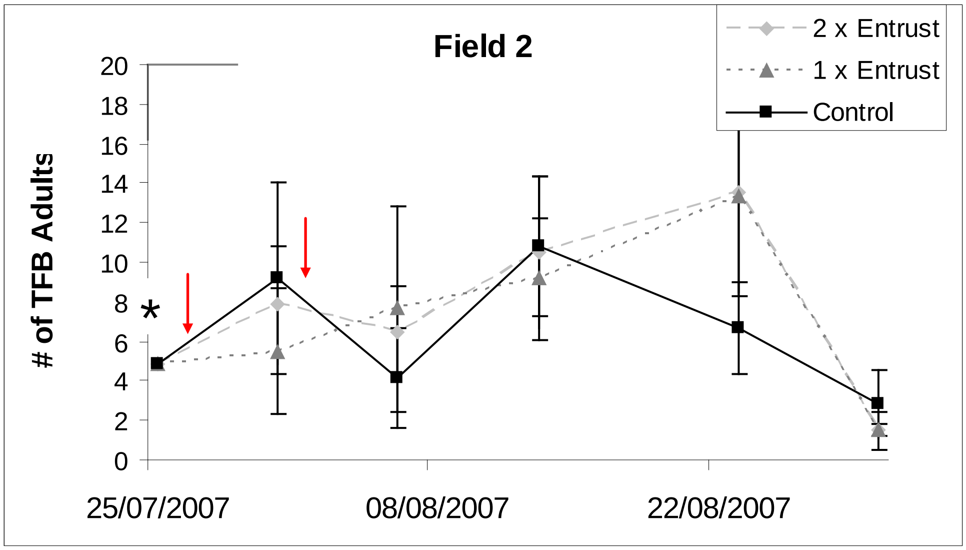

Figure 5 : Weekly catches of adult tuber flea beetles at Field 2, in plots treated with Entrust once, twice, or untreated controls. Bars represent standard error means for averages. Red arrows indicate spray dates in Entrust plots.

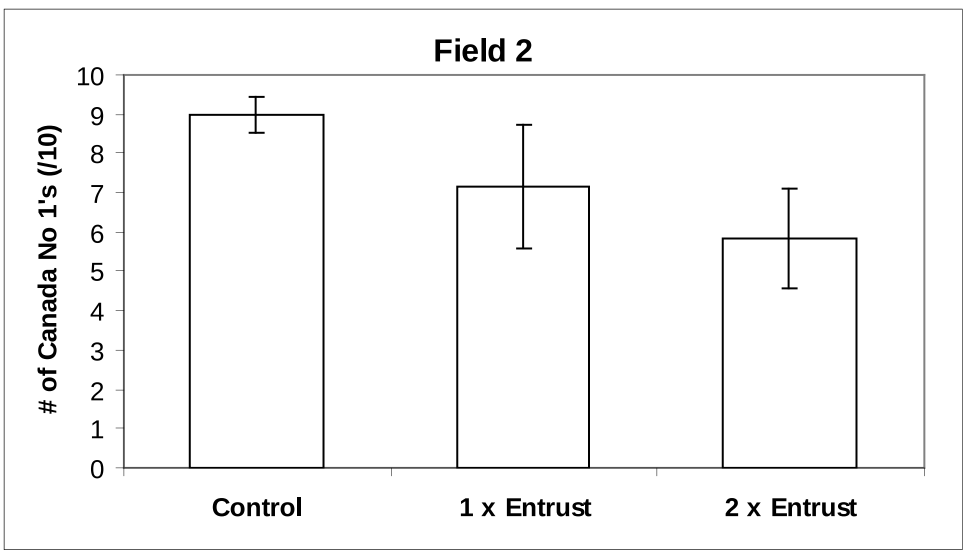

Figure 6: Effect of Entrust treatment, for tuber flea beetle control in Field 2, on the number of Canada No 1. grade tubers (i.e. < 5% of tuber weight with damage or defect) harvested from plots. Control treatment involved no insecticide applications for tuber flea beetle control. Bar represent the mean (± s.e.) number of potatoes out of 10 assessed from each plot. N=6 for each treatment.

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APPENDIX 1 Treatment locations in Fields 1 and 2