**2017 Progress Report to the**
**BC CRANBERRY RESEARCH COMMITTEE**

**Project Title: Project Title:** Assessment of new pest management tools that address priority needs of the BC cranberry industry

**Principal Investigator:** Kim Patten, Washington State University - Long Beach Research and Extension Unit, 2907 Pioneer Rd., Long Beach WA 98631, 360-642-2031, pattenk@wsu.edu.

**Project Summary:**
*Tipworm:* Studies were conducted on tipworm insecticide efficacy. Fenpropathrin and bifenthrin treatments in May were able to provide continued suppression into July. Carbaryl, novaluron + acetamiprid, and flonicamid applied in May all provided initial suppression, but control was short-lived. Spear (Vestron + Bti), had minimal efficacy. Fenpropathrin or bifenthrin could be an important tool for helping to managing tipworm resistance to Movento in the future. Based on emergence trap data, Altacor applied to cupped tips had no effect on tipworm larva or pupae. Second generation tipworm adults were caught in emergence traps over a two month period.

*Fungicide effects on yield components and fruit rot*: The effects of fungicide on total yield or yield of good fruit were minimal or inconsistent. Fruit size was reduced ~ 0.1 gram/fruit by in-bloom fungicide in 1/3rd of our studies. There was no consistent trend among varieties, fungicide treatments, or experiments for the effects of fungicides applied during bloom on percent fruit set, percent pinheads, or fruit/upright. There was a significant reduction in field rot with an in-bloom fungicide treatment compared to the untreated control in ~ 25% of our field trials. In trials, where the control plots had > 20% field rot, fungicides reduced field rot by 50%, but there was a minimal difference between what specific fungicide treatment was most effective for reducing field rot and storage rot. Fungicide treatment during bloom reduced fruit size in many of the field trials. Overall, our results suggest that there is only a subtle difference, if any, in efficacy against field rot, between application timings during bloom, and/or fungicides treatments/products.

*Light Trap:* Light traps were not efficacious in attracting girdler or tipworm to a level that would be considered practical. They could be an effective means to reduce cutworm population on a farm, if they were problematic.

**Progress Results**

*Objective 1: Assess control methodologies of cranberry tipworm that are relevant to BC conditions, acceptable for export markets and compatible with chemigation.*

*Methods:*
Experiment 1: Four sites with serious tipworm infestation were chosen. Treatment comparisons were untreated control, novaluron+ acetamiprid, carbaryl, flonicamid, Spear + *BTi*, and fenpropathrin. Plots will 6' x 6', with 6 replications per site. Treatments were applied three times, ~7 days apart, by hand at 1200 gpa. First timing was based on first observation of tipworm egg laying and larvae. Efficacy was based on percent uprights with first and second generation with tip curling, # larvae and pupae/25 uprights, and # cupped tip/ft$^2$. Of the four farms treated, only two provide suitable data for collection and analysis.

Experiment 2: An experiment was done to assess residual insecticide effects on second-generation tipworm development. Two sites with serious tipworm infestations were chosen. Treatment comparisons were untreated control, 3 pre-bloom applications of carbaryl + mid-bloom Altacor, 2 pre-bloom applications of bifenthrin + mid-bloom Altacor. Plots were 6' x 6', with 6 replications per site. Treatments were applied three times, ~7 days apart, by hand at 1200 gpa. Efficacy was based on percent uprights with second generation tip curling (early July) and # cupped tip/ft$^2$.

Experiment 3: An experiment was conducted to assess if rimon would prevent adult emergence from over-wintering tipworm pupae. Tipworm emergence traps were placed over duff infested with cranberry tipworm eggs at two farms. At each farm there were 12 control traps, and 12 traps had a duff layer inside the traps treated with rimon at label rate and chemigation volume, on 5/1/17, 5/8/17, 5/15/17, 5/22/17, 5/30/17. The total number of adults which emerged from with the traps were compared at the end of the summer.

Experiment 4. An experiment was conducted to assess if Altacor had any systemic effect on tipworm larvae and pupae. Tipworm emergence traps were placed over vines with a known number of infested uprights (cupped tips). There were two treatments: control and vines treated with Altacor. The total numbers of adults which emerged from the traps were compared at the end of the summer.

Experiment 5. An experiment was conducted to assess the duration of tipworm emergence from the duff layer compared to emergence from uprights with first generation infested tipworm. Four tipworm traps were placed side by side on a highly infested bed on vines with a known number of infested tips, and where the vine had been pulled back and only the duff layer exposed. The number of adults emerging was counted every 5 to 7 days from 6/1 to 8/24.

*Results:*
Experiment 1: Data from the number of larvae and pupae/25 uprights during assessment in June was variable, depending on the data and farm (Table 1a). The number of larvae and pupae was too low in Farm One to make solid inferences, but in Farm Two all treatments suppressed

tipworm. Based on the % cupped tips, however, all treatments showed some efficacy for the first assessment date, but only fenpropathrin provided consistent residual efficacy by the last assessment on 7/7/17. The residual 2$^{nd}$ generation efficacy is impressive considering that these were small plots within a large infested bed.

Experiment 2: Residual efficacy for 2$^{nd}$ generation tipworm was evident for bifenthrin, but not carbaryl (Table 2).

Experiment 3: Rimon had no effect on first generation tipworm larvae emergence from over-wintering pupae (Table 3).

Experiment 4: Altacor had no systemic effect on tipworm larva or pupae (Table 4, Figure 1).

Experiment 5: Second generation tipworm emerged over a two month period (Figure 1).

*Discussion:*
Historically, obtaining good tipworm efficacy data based on larvae and pupae counts has been difficult and is often inconsistent and highly variable. Data collected in 2017 confirm those results. Nevertheless, based on those results, several products, especially fenpropathrin, looked promising. Counting cupped uprights (% or density) provided another tool for assessment. Carbaryl and fenpropathrin both showed good reduction in early cupping, but only fenpropathrin and bifenthrin were able to provide continued suppression into July. Either one of these two chemistries could be an important tool for helping to managing tipworm in the future, especially if resistance issues occur with Movento.

Table 1a. 2017 Insecticide efficacy trials for cranberry tipworm*

| | Farm 1 | | | | | | Farm 2 | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6/6/2017 | | | 6/13/2017 | | | 6/20/17 | | |
| | # tipworm/25 uprights | | | | | | | | |
| Treatment | larvae | pupae | total | larvae | pupae | total | larvae | pupae | total |
| Control | 1.5 a | 0.3 a | 1.7 a | 0.1 b | 0.1 a | 1 a | 2.3 a | 2 a | 5 a |
| Sevin 2 qt/a | 0.1 b | 0 a | 0.1 a | 0 b | 0 a | 0 a | 0 b | 0 a | 0 b |
| Flonicamid (Beleaf) 2.8 oz/a | 0 b | 0.5 a | 0.1 a | 0 b | 0.3 a | 0.3 a | 0.1 b | 0 a | 0.1 b |
| Fenpropathrin (Danitol 16 oz/a) | 0 b | 0.3 a | 0.1 a | 0 b | 0.1 a | 0.1 a | 0 b | 0 a | 0 b |
| Spear Vestron + Bti** | 0.1 b | 0.3 a | 0.3 a | 0.9 a | 1.5 a | 2.6 a | 0.1 b | 0 a | 0.1 b |
| Novaluron + acetamiprid (Cormoran 12 oz/a) | 0 b | 0 a | 0 a | 0 b | 0 a | 0 a | 0.1 b | 0 a | 0.1 b |
| LSD P=.05 | 3.4 | 0.8 | 5.4 | 2.8 | 4.7 | 6.2 | 5.2 | 0.0 | 3.9 |
| Treat Prob(F)*** | 0.004 | 0.8 | 0.1 | 0.004 | 0.06 | 0.04 | 0.02 | 1 | 0.0001 |

*Farm 1, treated 5/19/17, 5/25/17 and 6/1/17; Farm 2 treated 5/19/17, 5/25/17, 6/1/17, and 6/22/17. Treatments were applied at 30 gpa.
*BTi was Gnatural
***Means followed by same letter do not significantly differ (P=.05, Student-Newman).

Table 1b. 2017 Insecticide efficacy trials for cranberry tipworm*.

| | Farm 1 | | | Farm 2 | |
|---|---|---|---|---|---|
| | % cupping | | | | |
| Treatment | 6/6/2017 | 6/13/2017 | 7/7/2017 | 6/20/2017 | 7/7/2017 |
| Control | 10.4 a | 2.4 a | 58 a | 22 a | 30 a |
| Carbaryl (Sevin 2 qt/a) | 0.4 b | 0.8 a | 59 a | 0 b | 10 bc |
| Flonicamid (Beleaf 2.8 oz/a) | 0.4 b | 2.8 a | 72.8 a | 3.6 b | 11.8 bc |
| Fenpropathrin (Danitol 16 oz/a) | 0.4 b | 4.8 a | 0.1 b | 0 b | 0 c |
| Spear Vestron + bti** | 1.2 b | 11.2 a | 65.3 a | 4.8 b | 23 ab |
| Novaluron + acetamiprid (Cormoran 12 oz/a) | 0.4 b | 0 a | 50 a | 1.6 b | 17.5 ab |
| Lsd p=.05 | 3.4 | 0.5 | 11.1 | 4.5 | 11.0 |
| Treat prob(f)*** | 0.004 | 0.2 | 0.0001 | 0.0001 | 0.0006 |

*Farm 1, treated 5/19/17, 5/25/17 and 6/1/17; Farm 2 treated 5/19/17, 5/25/17, 6/1/17, and 6/22/17. Treatments were applied at 30 gpa.
*BTi was Gnatural
***Means followed by same letter do not significantly differ (P=.05, Student-Newman-Keuls).

Table 1c. 2017 Insecticide efficacy trials of cranberry tipworm*

| | # cupped upright/ft2 on 7/7/17 | |
|---|---|---|
| Treatment | Farm 2 | Farm 1 |
| Control | 32.1 a | 50.3 a |
| Sevin 2 qt/a | 8.6 b | 42.3 a |
| Flonicamid (Beleaf) 2.8 oz/a | 20.1 ab | 67.7 a |
| Danitol (Fenpropathrin) 16 oz/a | 0.3 c | 1.2 b |
| Spear Vestron + bti** | 23.2 ab | 60.5 a |
| Cormoran 12 oz/a | 19.9 ab | 48.7 a |
| Lsd p=.05 | 10.5 | 12.2 |
| Treatment F | 10.4 | 18.6 |
| Treat Prob(F)*** | 0.0002 | 0.0001 |

*Farm 1, treated 5/19/17, 5/25/17 and 6/1/17; Farm 2 treated 5/19/17, 5/25/17, 6/1/17, and 6/22/17. Treatments were applied at 30 gpa.
*BTi was Gnatural
***Means followed by same letter do not significantly differ (P=.05, Student-Newman).

Table 2. 2017 Tipworm efficacy comparison between carbaryl and bifenthrin*

| Treatment | Farm 3 | Farm 4 | Farm 3 | Farm 4 |
|---|---|---|---|---|
| | # cupped tips/ $ft^2$ 7/7/17 | | % cupped tips 7/7/17 | |
| Control | 65 a | 33.1 a | 82.5 a | 31.9 a |
| Bifenthrin 5/17 & 5/25) + Altacor 6/27 | 35.5 b | 3.3 b | 42.5 b | 0.7 b |
| Carbaryl (5/17, 5/25 &6/2) + Altacor 6/27 | 75 a | 30.4 a | 86.3 a | 20.8 a |
| Lsd p=.05 | 12.3 | 1.0 | 9.8 | 0.3 |
| Treatment F | 33 | 49 | 72 | 52 |
| Treat prob(f)** | 0.0006 | 0.0002 | 0.0001 | 0.0002 |

* Treatments were applied at 60 gpa.
**Means followed by same letter do not significantly differ (P=.05, Student-Newman).

Table 3. 2017 Tipworm efficacy study on the use of rimon to control overwintering pupae* .

| Treatment | # tipworm adults/ trap | |
|---|---|---|
| | Farm 1 | Farm 2 |
| Control | 0.1 | 0 |
| Rimon | 0.1 | 0.2 |
| LSD P=.05 | 0.25 | 0.25 |
| Treatment F | 0 | 0 |
| Treat Prob(F) | 1 | 1 |

* Treatments were applied at 3000 gpa on 5/1/17, 5/8/17, 5/15/17, 5/22/17 & 5/30/17

Table 4. 2017 Efficacy trials on the efficacy of Altacor on tipworm larvae and pupae already in cupped tips.

| Treatment | # tipworm/ trap |
|---|---|
| Control | 8.9 |
| Altacor | 7.5 |
| LSD P=.05 | 0.2 |
| Treatment F | 0.8 |
| Treat Prob(F) | 0.4 |

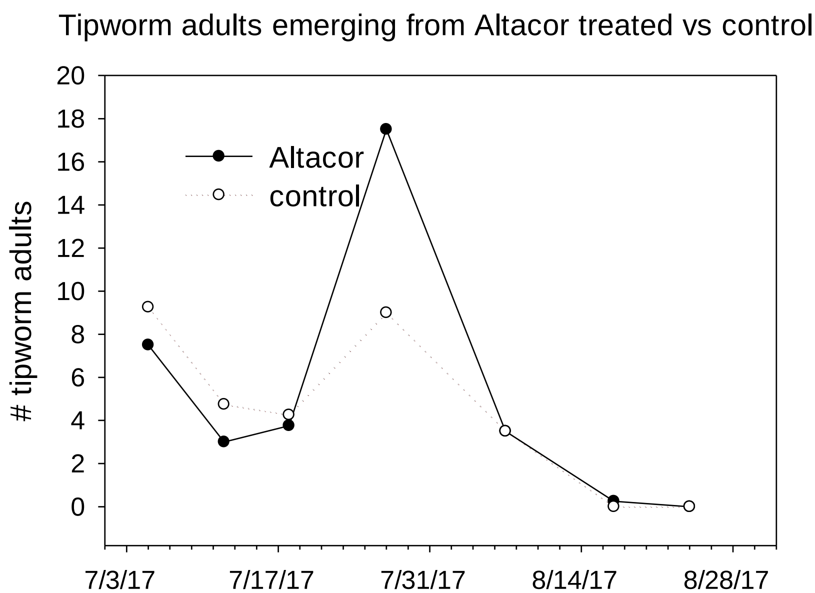


Figure 1. 2017 Tipworm emergence on Altacor treated and untreated tipworm-infested uprights over time.

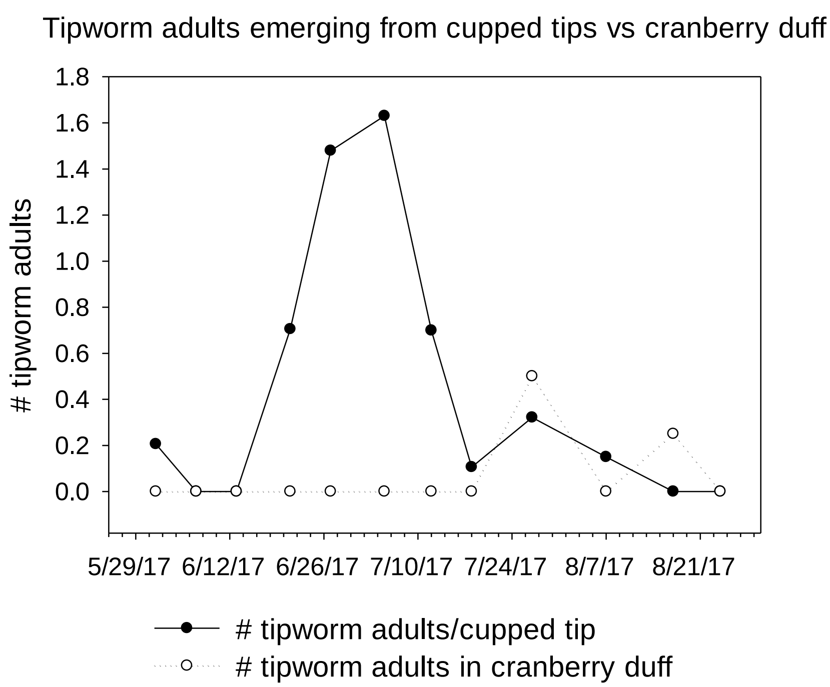


Figure 2. 2017 Tipworm emergence on tipworm-infested uprights compared to cranberry duff with the vine removed.

*Objectives 2 & 3: Effect of fungicide alternatives on yield components of cranberries and fruit rot.*

*Methods:* In 2017, we assessed the efficacy of various alternative chlorothalonil-free fungicide programs that address efficacy and resistance management for cranberry fruit rot. Research trials on alternative fungicides were applied at chemigation spray volume, unless otherwise specified. Plots were 6' x 6' plots in 6 replications per site. Treatments were applied to different varieties (Stevens, Crimson Queen, Willapa Red, Welker, Pilgrim, and BG) at sites with a previous history of high field rots. Total yield, yield of good fruit, percent field rot, and fruit size were assessed after harvest. In four of the trials yield components associated with fruit set (# flowers, # fully set fruit, # pinheads fruit), were collected in early August on 50 random upright per plots. Mean % fruit set, % pin-heads, and fruit/upright were calculated.

*Yield components results:*
Yield: The effects of fungicide on total yield or yield of good fruit in 2017 were minimal or inconsistent. In one experiment, two in-bloom Proline + a late bloom Bravo reduced yield of good fruit compared to the control (Table 5). In nine other experimental trials (Tables 6, 10, 11, 12, 13, 14, 15, 16, 17) there was no effect of bloom-applied fungicide on yield. In two trials some of the fungicide treatments improved the total amount of good fruit. In one of them, three applications of Switch, Propulse, Proline + Abound, or an Abound, Proline, Bravo treatment all increased yield of Stevens compared the control (Table 6). In another trial, Proline + Abound, or a Proline -Abound rotation showed a trend to increase the amount of good BG fruit compared to the control (Table 7). Three of our trials made an effort to assess if bloom-applied Bravo affected yield. For Willapa Red, late bloom Bravo reduced yield (Table 5), but for Stevens there was no effect of early or late bloom Bravo (Tables 6 & 7).

Fruit size: Fruit size was affected by in-bloom fungicide treatments in 5 of the 12 trials (Table 7, 9, 10, 11, 13, 18). In one studied it was increased 17% by Switch treatment (Table 7), but in all other studies where fruit size was effected, the impact of fungicide was negative (averaging 8% decrease ~ 0.1 gram/fruit.

Fruit set and fruit per upright: There were several notable results for the effect of fungicide on fruit set yield components. A Proline + Bravo treatment during bloom reduced set and number of fruits per upright on Stevens and Willapa Red, compared to the control and other fungicide treatments (Table 19. Proline + Abound (three times during bloom) slightly reduced fruit/upright on Stevens compared to the control in one study (Table 20), but had no effect on Stevens and Willapa Red in another study (Table 21). Propulse, Quadris Top, Propulse during bloom reduced fruit per upright on Willapa Red and reduced the % pinhead on Pilgrim compared to the untreated control (Table 22).

*Yield component discussion*:
Overall, the minimal effects of fungicide on total yield or yield of good fruit were unexpected considering the high variation in yield in fungicide plots. This has been a consistent problem with previous fungicide trials. Although great care is exercised when applications are made to avoid stepping within the plots during treatments, some damage to bloom could inadvertently occur when three to five treatments were applied during bloom. When we take out the

occasional outlier data points for low yield that could be attributed to tramping damage, then none of the trials showed a negative effect of fungicide on yield.

The results on fruit size are surprising. Data from New Jersey indicates that Abound has a growth hormone effect and increases fruit size. Under our experimental conditions, significantly greater fruit size was often found in the untreated control plots. In addition, in some of these sites the untreated control also had a higher number of fruit per upright than the fungicide-treated plots. This suggests that there could be a subtle repellency effect of some fungicide treatments on pollinators that might slightly reduce the fruit size (lower seed count) and number of fruit per upright. In one experiment, it was also noted that there was a consistent reduction in set with the Proline + Bravo treatment compared to untreated control or fungicide treatment without Bravo (Table 18). These could be just random noise, but additional data should be collected to make sure this is not the case.

*Field rot results:*
The effects on bloom-applied fungicide on field rot were inconsistent. In 8 of the 13 trials there was no treatment effect on % fruit rot (Tables 6, 8, 9, 11, 12, 15, 17). In two trials, where the control plots had > 20% field rot, fungicide reduced field rot by 50% (Tables 5, 7). In these two trials there were minimal differences in which specific fungicide treatment was most effective for reducing field rot. In three trials, the in-bloom use of fungicides increased field rot compared to the control (Table 11, 154, 17). In three trials we assessed, post-set fungicide reduced fruit set. There was no indication that post-set fungicide (ManKocide and Bravo) applications, either supplemental to in-bloom fungicides, or as a stand-alone application) reduced fruit rot (Tables 10, 11, and 12).

There was a confounding variable that affected % field rot. Individual plots with very high yield tended to have excessive field rot (Figure 3). For experiments on Willapa Red, these outliers negated the fungicide effects on field rot. When those few outliers were removed from the analysis, 5 fungicide applications were more effective than a combined application of two fungicides applied twice (Table 14).

*Storage rot results:*
We only evaluated storage in trials we there was significant field rot levels. The effects on bloom-applied fungicide on storage rot were inconsistent. In 6 of the 10 trials there was no treatment effect on % storage rot (Tables 5, 9, 10, 12, 15, 17). In four trials, bloom applied fungicides reduced storage ort (Tables 7, 14, 15, 16). The efficacy of fungicide for storage rot followed the same significance as for field rot. The only exception was for Willapa Red where there was difference for storage rot, but not field rot (Table 17).

*Fruit rot discussion*:
We had a significant reduction in field rot with in-bloom fungicide compared to the untreated control in ~ 25% of our field trials. In studies where fungicide treatment reduced field rot or storage rot, there was no discernable difference between fungicides or number of fungicide applications. This suggests that there are at best only subtle differences between timings (5 to 20% differences in % bloom), or combination of fungicides (Proline + Abound) vs. Proline or Abound alone vs. single products, or products (Proline, Indar, Propulse, Quadris Top, Switch).

These differences might be noted when there are conditions for high field rot (> 20%), but would not be detected when conditions favor low field rot.  There appears to be no specific magic timing and treatment combination that consistently works best for field or storage rot.  Rather, it is more probable that any array of treatments applied over bloom will provide similar efficacy for field rot.  Confounding variables within a bed will also affect the response to fungicide treatment.  Areas of thick uprights and high yield will respond better to more rigorous fungicide treatments.

Table 5. Effect of fungicides during yield, fruit rot and fruit size of Willapa Red cranberries in 2017

| Treatment | bbl/ac total | bbl/ac good | % field rot | fruit size g/fruit | % storage rot |
|---|---|---|---|---|---|
| Untreated control | 280 a | 221 b | 21 a | 1.20 a | 14.7 a |
| Proline 10-20% bloom, Proline 40-60% bloom, Bravo 70 to 80 % bloom | 132 a | 117 a | 11 b | 1.12 a | 7.5 a |
| Proline+ Abound 10-20% bloom, Indar+Abound 40-60% bloom, Proline +Abound 70 to 80 % bloom. | 193 a | 165 ab | 13 ab | 1.15 a | 8.9 a |
| Propulse 10-20% bloom, Quadris Top 40-60% bloom , Propulse 70 to 80 % bloom | 197 a | 170 ab | 13 ab | 1.31 a | 8.2 a |
| LSD | 75 | 57 | 7 | 0.14 | 2.9 |
| Probability of significance | 0.13 | 0.01 | 0.03 | 0.06 | 0.07 |

Treatments applied at 110 gpa on 6/12/17, 6/19/17 and /6/23/17.
Means followed by same letter do not significantly differ (P=.05, Student-Newman-Keuls).

Table 6. Effect of fungicides during yield, fruit rot and fruit size of Stevens cranberries in 2017.

| Treatment | bbl/ac total | bbl/ac good | % field rot | fruit size g/fruit |
|---|---|---|---|---|
| Untreated control | 144 a | 118 a | 15.2 a | 1.39 a |
| Proline 10-20% bloom, Proline 40-60% bloom, Bravo 70 to 80 % bloom | 150 a | 128 a | 13.5 a | 1.33 a |
| Proline+ Abound 10-20% bloom, Indar+Abound 40-60% bloom, Proline +Abound 70 to 80 % bloom. | 116 a | 99 a | 12.6 a | 1.37 a |
| Propulse 10-20% bloom, Quadris Top 40-60% bloom , Propulse 70 to 80 % bloom | 130 a | 113 a | 12.0 a | 1.44 a |
| LSD | 48 | 44 | 0.26 | 0.17 |
| Probability of significance | 0.4 | 0.6 | 0.9 | 0.62 |

Treatments applied at 110 gpa on 6/12/17, 6/19/17 and /6/23/17.
Means followed by same letter do not significantly differ (P=.05, Student-Newman-Keuls).

Table 7. Effect of fungicides during yield and fruit rot on Stevens cranberries in 2017.

| Treatment | bbl/ac total | bbl/ac good @ harvest | bbl/ac good after storage | % field rot | % storage rot | Fruit size (g/fruit) |
|---|---|---|---|---|---|---|
| Control | 180 a | 133 b | 128 b | 24.6 a | 18.2 a | 1.29 b |
| Quadris Top 6/12, 6/19, & 6/25 | 192 a | 169 ab | 160 ab | 11.0 b | 10.7 ab | 1.34 b |
| Switch 6/12, 6/19, & 6/25 | 243 a | 211 a | 199 a | 12.3 b | 9.9 b | 1.51 a |
| Propulse 6/12, 6/19, & 6/25 | 245 a | 207 a | 194 a | 14.1 b | 11.2 ab | 1.34 b |
| Proline + Abound 6/12, 6/19, & 6/25 | 212 a | 181 a | 174 ab | 14.0 b | 13.2 ab | 1.48 ab |
| Abound 6/12, Proline 6/19, Bravo 6/25 | 209 a | 184 a | 174 ab | 10.3 b | 16.3 ab | 1.31 b |
| Bravo 6/12, Abound 6/19, Proline 6/25 | 212 a | 176 ab | 166 ab | 15.6 b | 14.6 ab | 1.27 b |
| Treatment F | 1.31 | 2.11 | 2.2 | 3.31 | 2.3 | 6.2 |
| Treatment Prob(F) | 0.278 | 0.058 | 0.06 | 0.011 | 0.05 | 0.0002 |

Treatment s applied at 275 gpa. Means followed by same letter do not significantly differ (P=.05).

Table 8. Effect of fungicides during yield and fruit rot on Pilgrim cranberries in 2017.

| Treatment | bbl/ac total | bbl/ac good | % field rot |
|---|---|---|---|
| Control | 286 ab | 248 a | 12.9 a |
| Quadris Top 6/12, 6/19, & 6/25 | 279 ab | 243 a | 12.3 a |
| Switch 6/12, 6/19, & 6/25 | 201 b | 180 a | 10.3 a |
| Propulse 6/12, 6/19, & 6/25 | 285 ab | 253 a | 10.9 a |
| Proline + Abound 6/12, 6/19, & 6/25 | 308 a | 255 a | 15.7 a |
| Abound 6/12, Proline 6/19, Bravo 6/25 | 253 ab | 255 a | 11.6 a |
| Bravo 6/12, Abound 6/19, Proline 6/25 | 246 ab | 208 a | 15.0 a |
| Treatment F | 2.4 | 2.1 | 3.31 |
| Treatment Prob(F) | 0.05 | 0.08 | 0.011 |

Treatment s applied at 275 gpa. Means followed by same letter do not significantly differ (P=.05).

Table 9.  Effect of fungicides during yield and fruit rot of BG cranberries in 2017.

| Treatment | total bbl/ac | bbl/ac good | % field rot | % storage rot | Fruit size (g/fruit) |
|---|---|---|---|---|---|
| Control | 342 a | 260 a | 18.4 a | 16. 5 a | 1.67 a |
| Proline + Abound 6/8 & 6/16 | 380 a | 346 b | 8.7 a | 9.25 a | 1.56 b |
| Proline 6/8, Abound 6/12, Proline 6/16, Abound 6/23, Proline 6/25 | 418 a | 372 b | 10.2 a | 10.25 a | 1.51 b |
| Treatment F | 1.97 | 3.50 | 2.85 | 1.2 | 4.1 |
| Treatment Prob(F) | 0.20 | 0.06 | 0.12 | 0.33 | 0.06 |

Treatments applied at 250 gpa.  Analysis done using by ANOVA on ranks.
Means followed by same letter do not significantly differ (P=.10)

Table 10.  Effect of fungicides during yield and fruit rot of   Welker cranberries in 2017.

| Treatment | total bbl/ac | bbl/ac good | % field rot | % storage rot | Fruit size (g/fruit) |
|---|---|---|---|---|---|
| Control | 165 a | 151 a | 8.3 a | 8.1 a | 1.89 a |
| Proline + Abound 6/12, 6/19, 6/25 | 155 a | 143 a | 8.1 a | 5.0 a | 1.74 a |
| Bravo 7/11 & 7/17; ManKocide 7/26 & 8/7 | 185 a | 166 a | 10.1 a | 8.2 a | 1.76 a |
| Proline + Abound 6/12, 6/19, 6/25; Bravo 7/11 & 7/17; ManKocide 7/26 & 8/7 | 196 a | 178 a | 8.8 a | 5.8 a | 1.82 a |
| Treatment F | 1.8 | 1.1 | 0.1 | 2.8 | 0.7 |
| Treatment Prob(F) | 0.20 | 0.39 | 0.94 | 0.08 | 0.5 |

Treatment s applied at 115 gpa. Means followed by same letter do not significantly differ (P=.05)

Table 11.  Effect of fungicides during yield and fruit rot of   Demoranville cranberries in 2017.

| Treatment | total bbl/ac | bbl/ac good | % field rot | g/ fruit |
|---|---|---|---|---|
| Control | 119 a | 113 a | 4.22 b | 1.84 a |
| Proline + Abound 6/12, 6/19, 6/25 | 111 a | 99 a | 12.5 a | 1.52 b |
| Bravo 7/11 & 7/17; ManKocide 7/26 & 8/7 | 144 a | 135 a | 6.08 ab | 1.77 a |
| Proline + Abound 6/12, 6/19, 6/25; Bravo 7/11 & 7/17; ManKocide 7/26 & 8/7 | 108 a | 97 a | 10.11 ab | 1.53 b |
| Treatment F | 1.4 | 1.7 | 3.6 | 12.9 |
| Treatment Prob(F) | 0.26 | 0.20 | 0.04 | 0.0005 |

Products applied at @110 gpa.  Means followed by same letter do not significantly differ (P=.05)

Table 12. Effect of fungicides during yield and fruit rot of Stevens cranberries in 2017.

| Treatment | total bbl/ac | bbl/ac good | % field rot | Fruit size g/fruit | Storage rot % |
|---|---|---|---|---|---|
| Control | 129 a | 122 a | 5.1 | 1.31 a | 8.7 a |
| Proline + Abound 6/12, 6/19, 6/25 | 158 a | 151 a | 4.4 a | 1.34 a | 7.5 a |
| Bravo 7/11 & 7/17; ManKocide 7/26 & 8/7 | 134 a | 128 a | 3.8 a | 1.35 a | 10.6 a |
| Proline + Abound 6/12, 6/19, 6/25; Bravo 7/11 & 7/17; ManKocide 7/26 & 8/7 | 128 a | 124 a | 2.6 a | 1.32 a | 8.4 a |
| Treatment F | 1.3 | 1.2 | 1.3 | 0.2 | 0.7 |
| Treatment Prob(F) | 0.3 | 0.3 | 0.3 | 0.8 | 0.6 |

Products applied at @110 gpa. Means followed by same letter do not significantly differ (P=.05)

Table 13. Effect of fungicides application frequencies on yield and fruit rot of Stevens cranberries in 2017.

| Treatment | total bbl/ac | bbl/ac good | % field rot | % storage rot | g/ fruit |
|---|---|---|---|---|---|
| Control | 206 a | 179 a | 13 a | 10.1 a | 1.54 a |
| Proline + Abound 6/16 & 6/23 | 187 a | 171 a | 8.3 a | 8.4 a | 1.43 b |
| Proline 6/16, 6/27; Abound 6/23, Proline + Abound 7/11 | 155 a | 140 a | 9.3 a | 11.4 a | 1.34 b |
| Treatment F | 2.3 | 1.7 | 2.2 | 1.7 | 24.6 |
| Treatment Prob(F) | 1.4 | 0.22 | 0.15 | 0.2 | 0.0001 |

Products applied at @100 gpa. Means followed by same letter do not significantly differ (P=.05)

Table 14. Effect of fungicides application frequencies on yield and fruit rot of Willapa Red cranberries in 2017.

| Treatment | total bbl/ac | bbl/ac good | % field rot* | % field rot** | % storage rot** | g/ fruit |
|---|---|---|---|---|---|---|
| Control | 344 a | 251 a | 25.3 a | 22.7 ab | 20.8 a | 1.12 a |
| Proline + Abound 6/16 & 6/23 | 377 a | 276 a | 25.9 a | 25.9 b | 24.4 a | 1.11 a |
| Proline 6/16, 6/27; Abound 6/23, Proline + Abound 7/11 | 347 a | 261 a | 20.6 a | 13.7 a | 9.3 b | 1.14 a |
| Treatment F | 0.8 | 1.2 | 0.3 | 4.6 | 5.3 | 0.2 |
| Treatment Prob(F) | 0.5 | 0.3 | 0.7 | 0.04 | 0.03 | 0.8 |

Products applied at @115 gpa. Means followed by same letter do not significantly differ (P=.05)
* % field rot not adjusted for yield
** % field rot adjusted for yield

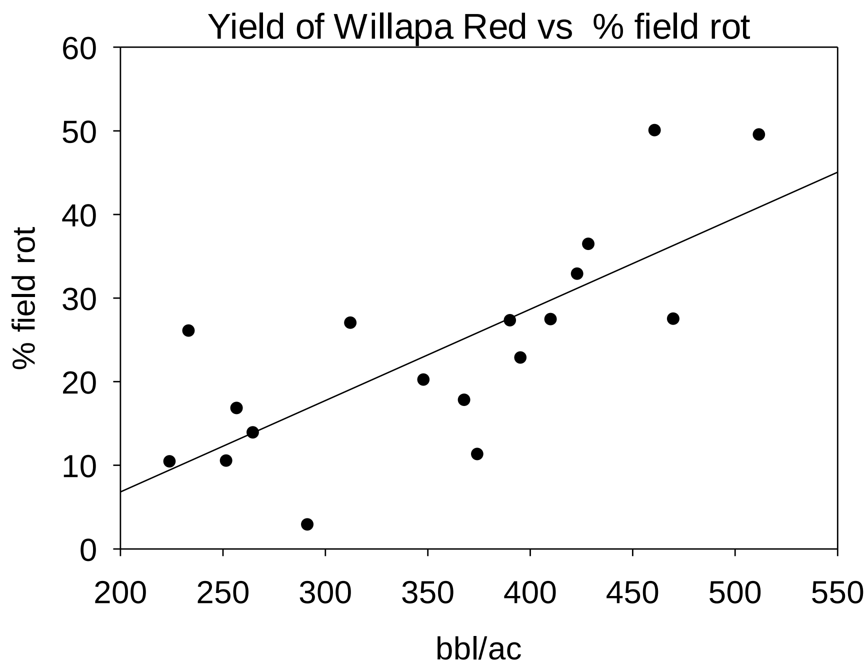


Figure 3. Relationship of yield and % field rot of Willapa Red within individual research plots.

Table 15. Effect of fungicides during yield, fruit rot and fruit size of Crimson Queen cranberries in 2017.

| Treatment | bbl/ac total | bbl/ac good fruit | % rot harvest | g/fruit | Storage rot % |
|---|---|---|---|---|---|
| Control | 173 a | 155 a | 10.4 a | 1.59 a | 16.1 a |
| Proline + Abound 6/2/17 6/23/17; Indar + Abound 6/16/17; | 232 a | 219 a | 5.3 b | 1.54 a | 4.8 b |
| Propulse 6/12/17 & 6/23/17; Quadris Top 6/16/17 | 196 a | 183 a | 6.9 b | 1.58 a | 7.6 b |
| Treatment F | 1.1 | 1.4 | 3.8 | 0.2 | 15.1 |
| Treatment Prob(F) | 0.38 | 0.29 | 0.05 | 0.82 | 0.001 |

Products applied at @115 gpa. Means followed by same letter do not significantly differ (P=.05)

Table 16. Effect of fungicides during yield, fruit rot and fruit size of Mullica Queen cranberries in 2017.

| Treatment | bbl/ac total | bbl/ac good fruit | % rot harvest | g/fruit | Storage rot % |
|---|---|---|---|---|---|
| Control | 321 a | 286 a | 9.3 a | 1.57 a | 7.8 a |
| Proline + Abound 6/2/17 6/23/17; Indar + Abound 6/16/17; | 294 a | 280 a | 4.5 b | 1.56 a | 2.4 b |
| Propulse 6/12/17 & 6/23/17; Quadris Top 6/16/17 | 336 a | 318 a | 4.7 b | 1.49 a | 3.1 b |
| Treatment F | 1.1 | 1.3 | 5.4 | 0.9 | 210.7 |
| Treatment Prob(F) | 0.36 | 0.31 | 0.02 | 0.40 | 0.033 |

Products applied at @115 gpa. Means followed by same letter do not significantly differ (P=.05)

Table 17. Effect of fungicides during yield, fruit rot and fruit size of Willapa Red cranberries in 2017.

| Treatment | bbl/ac total | bbl/ac good fruit | % rot harvest | g/fruit | Storage rot % |
|---|---|---|---|---|---|
| Control | 205 a | 194 a | 4.6 a | 1.18 a | 14.7 a |
| Proline + Abound 6/2/17 6/23/17; Indar + Abound 6/16/17; | 163 a | 155 a | 3.2 a | 1.05 a | 7.5 a |
| Propulse 6/12/17 & 6/23/17; Quadris Top 6/16/17 | 190 a | 181 a | 3.6 a | 1.11 a | 8.9 a |
| Treatment F | 1.8 | 1.8 | 0.4 | 1.7 | 2.9 |
| Treatment Prob(F) | 0.20 | 0.20 | 0.70 | 0.20 | 0.7 |

Products applied at @115 gpa. Means followed by same letter do not significantly differ (P=.05)

Table 18. Effect of fungicides during yield, fruit rot and fruit size of Pilgrim cranberries in 2017.

| Treatment | bbl/ac total | bbl/ac good fruit | % rot harvest | g/fruit |
|---|---|---|---|---|
| Control | 278 a | 155 a | 10.4 a | 1.57 a |
| Proline + Abound 6/2/17 6/23/17; Indar + Abound 6/16/17; | 254 a | 219 a | 5.3 b | 1.34 c |
| Propulse 6/12/17 & 6/23/17; Quadris Top 6/16/17 | 260 a | 183 a | 6.9 b | 1.44 b |
| Treatment F | 0.37 | 0.46 | 0.9 | 43.7 |
| Treatment Prob(F) | 0.69 | 0.6 | 0.43 | 0.0001 |

Table 19. Effect of fungicides during bloom on fruit set, pinhead and fruit per upright of Stevens and Willapa Red cranberries in 2017.

| Treatment | Stevens | | | Willapa Red | | | Combined varieties | |
|---|---|---|---|---|---|---|---|---|
| | %fruit set | % pin-head | fruit/ upright | % fruit set | % pin-head | fruit/ upright | % fruit set | fruit/ upright |
| Untreated control | 0.59 ab | 0.05 | 2.15 | 0.71 b | 0.07 | 2.67 | 0.64 b | 2.36 b |
| Proline, Proline, Bravo | 0.51 a | 0.06 | 1.85 | 0.58 a | 0.06 | 1.94 | 0.54 a | 1.91 a |
| Proline+ Abound, Indar+Abound, Proline +Abound. | 0.66 b | 0.05 | 2.03 | 0.71 b | 0.06 | 2.37 | 0.7 b | 2.25 b |
| Propulse, Quadris, Propulse | 0.58 ab | 0.05 | 2.04 | 0.68 ab | 0.05 | 2.59 | 0.63 b | 2.3 b |
| LSD | 0.03 | 0.01 | 0.07 | 0.03 | 0.01 | 0.17 | 0.02 | 0.08 |
| Probability of significance | 0.02 | 0.5 | 0.17 | 0.06 | 0.5 | 0.05 | 0.01 | 0.01 |

Data corresponds to treatment and yield data present in Tables 5 &6.
Products applied at @110 gpa at 10% bloom (6/12), 50% bloom (6/19) and 70% bloom (6/23).
Means followed by same letter do not significantly differ (P=.05, Student-Newman-Keuls)

Table 20. Effect of fungicides during bloom on fruit set of Stevens cranberries in 2017

| Treatment | %set | %pinhead | fruit/upright |
|---|---|---|---|
| Untreated control | 0.34 | 0.10 | 1.25 a |
| Proline+ Abound 3x (6/12, 6/17, 6/23) | 0.30 | 0.07 | 1.21 b |
| Bravo 2x (7/11, 7/25) ManKocide (7/25, 8/7) | 0.35 | 0.07 | 1.23 ab |
| LSD | 0.02 | 0.02 | 0.07 |
| Probability of significance | 0.2 | 0.5 | 0.01 |

Data corresponds to the first three treatments in table 11.
Treatments applied at 100 gpa.
Means followed by same letter do not significantly differ (P=.05, Student-Newman-Keuls)

Table 21 Effect of Proline+Abound on fruit set of Stevens and Willapa Red cranberries in 2017

| Treatment | Stevens | | | Willapa Red | | |
|---|---|---|---|---|---|---|
| | %set | %pinhead | fruit/upright | %set | %pinhead | fruit/upright |
| Untreated control | 0.49 | 0.04 | 1.71 | 0.73 | 0.08 | 2.44 |
| Proline+Abound | 0.44 | 0.08 | 1.54 | 0.71 | 0.06 | 2.45 |
| Probability of significance | ns | ns | ns | ns | ns | ns |

Data corresponds to treatment and yield data present in Tables 12 & 13.
Means followed by same letter do not significantly differ (P=.05, Student-Newman-Keuls)

Table 22. Effect of fungicides during bloom on fruit set of Willapa Red, Pilgrim, Mullica Queen and Crimson Queen cranberries in 2017.

| Treatment | Willapa Red | | | Pilgrim | | |
|---|---|---|---|---|---|---|
| | % fruit set | % pin head | fruit /upright | % fruit set | % pin head | fruit /upright |
| Untreated control | 0.34 | 0.06 | 1.20 a | 0.52 | 0.18 b | 1.14 |
| Proline+Abound; Indar + Abound, Proline+ Abound | 0.35 | 0.07 | 1.25 ab | 0.57 | 0.16 ab | 1.30 |
| Propulse, Quadris Top, Propulse | 0.39 | 0.06 | 1.41 b | 0.57 | 0.13 a | 1.27 |
| LSD | 0.02 | 0.01 | 0.06 | 0.03 | 0.01 | 0.06 |
| Probability of significance | 0.09 | 0.6 | 0.08 | 0.5 | 0.03 | 0.2 |

| | Mullica Queen | | | Crimson Queen | | |
|---|---|---|---|---|---|---|
| Treatment | % fruit set | % pin-head | Fruit /upright | % fruit set | % pin head | Fruit /upright |
| Untreated control | 0.43 | 0.47 | 1.62 | 0.64 | 0.29 | 1.87 |
| Proline+Abound; Indar + Abound, Proline+ Abound | 0.43 | 0.47 | 1.60 | 0.61 | 0.29 | 1.83 |
| Propulse, Quadris Top, Propulse | 0.44 | 0.45 | 1.59 | 0.60 | 0.30 | 1.83 |
| LSD | 0.02 | 0.02 | 0.10 | 0.02 | 0.02 | 0.05 |
| Probability of significance | 0.1 | 0.2 | 0.1 | 1.5 | 0.2 | 0.2 |

Data corresponds to treatment and yield data present in Tables 14, 15, 16 & 17
Products applied at @115 gpa at 10-20% bloom (6/12), 40-60% bloom (6/19) and 70-80% bloom (6/23).
Means followed by same letter do not significantly differ (P=.05, Student-Newman-Keuls)

*Objective 4: Evaluate if cranberry girdler and tipworm populations can be suppressed using solar powered light trap technology*.

*Method:* Green Future solar based light traps were placed on dikes next to four cranberry beds with moderate populations of cranberry girdler. To assess girdler trapping efficacy, comparative trapping counts were made in pheromone traps placed around the bed. Each site also had a pheromone trap near the light trap and one 100' away. After first girdler flight was noted in pheromone traps, trap count data were collected every 4-5 days at the light trap and pheromone trap next to the light trap. During peak trapping days for the light trap, we also collected pheromone trap data 100' away from the light source for each location.

Data were also collected on number of cutworms and tipworm collected in the light trap over time. Quantifying the number of tipworm and girdler per trap was challenging. Tipworm were damaged by trapping and could not be easily discerned from other midge species. Many girdler moths were destroyed by larger cutworm moth attempting to escape after they were trapped. Cutworm worms were not ID by species, but included Alfalfa Lopper, *Ochropleura implecta*, False Armyworm, Zebra Caterpillar and Tussock Moth.

*Results:* Pair T-test comparisons were made for mean girdler moth catch per day. There was no difference in girdler trap counts between the light trap and adjacent pheromone trap (Table 23). The pheromone traps 100' away from the light trap had numerically higher count, not significantly different than the pheromone trap next to the light trap, (Table 24).

Trap catch data on tipworm, cutworm and fireworm were minimal. This was due to the difficulty of finding and discerning these insects in the collection bag. Verified tipworm and fireworm counts averaged less than 1 tipworm or fireworm /day/trap.

*Discussion:* These results indicate that light traps were not effective in attracting girdler to a level any more effective than a pheromone trap. It also indicates that the ability of the light traps to reduce girdler population on a bed, if at all, would be very limited in range (<100'). Furthermore, from a pragmatic purpose, these traps seemed to have limited ability to attract tipworm and fireworm. However, they could be an effective means to reduce cutworm population on a farm. Cutworm have been noted to be pests on cranberry beds in BC (See IPM for Cranberries in Western Canada, Fitzpatrick e al. 2015).

Table 23. Comparison of light trap and pheromone trapping for cranberry girdler trapping in 2017

| Treatment | Mean girdler moths/day |
|---|---|
| Pheromone trap near light trap | 0.6±0.2 |
| Light trap | 1.4±0.6 |
| One-tailed P-value | 0.13 |
| Mean of 4 sites, counts every 4-5 days over 4 weeks during peak flight | |

Table 24. Comparison of pheromone count for girdler as a function of distance from light trap in 2017.

| Treatment | Mean girdler moths/day |
|---|---|
| Pheromone trap near light trap | 0.3±0.1 |
| Pheromone 100’ away from light trap | 0.9±0.3 |
| One-tailed P-value | 0.12 |
| Mean of 4 sites, counts every 4 to 5 days  over 2 weeks during peak flight | |