2017 Field Evaluation of Insecticide Application Strategies for Colorado Potato Beetle Control (Year 3 of 3)

RESEARCH TEAM:
Dr. Tracy Shinners-Carnelley, Vice President Research & Quality
Peak of the Market, Tracy@PeakMarket.com

Darin Gibson and Debbie Jones, Gaia Consulting Ltd., Portage la Prairie, MB

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BACKGROUND:
The Colorado potato beetle (CPB) (*Leptinotarsa decemlineata)* is a major economic insect pest of potato production in Manitoba. The ability of this insect to develop resistance to insecticides further adds to the challenges of effective management. In the 1990's the neonicotinoid class of insecticides (Group 4) was introduced and proved to be a very effective insecticide for CPB. In 2011 suspicion of reduced efficacy of the neonicotinoid chemistry was observed in the field and later confirmed by Dr. Ian Scott of Agriculture and Agri-Food Canada.

Now that resistance to the neonicotinoid insecticides has been documented in Manitoba, it is important that growers evaluate new strategies for CPB and insect management in general. Since the introduction of neonicotinoid insecticides, spinosyns (Group 5) and the diamides (Group 28) have been registered. These insecticides have not gained widespread use in the potato industry, likely due to concerns about efficacy, precision of application timing, narrow pest spectrum and cost. This research will provide knowledge on effective strategies to manage CPB and assist growers in implementing an effective insect management strategy.

OBJECTIVE
The objective of this three-year project was to evaluate insecticide management strategies, including a combination of registered seed treatments, in-furrow, and/ or foliar insecticides for the control of Colorado potato beetle and other potato pests like aphids and leafhoppers. The strategies will be assessed for efficacy against these pests, the impact on potato yield and quality, the cost, and ease of implementation at the farm level.

METHODS
The project was conducted at the Peak of the Market Research Site in Winkler, MB, where a CPB population with mixed resistance to neonicotinoids is located. The trial was a 15 treatment randomized complete block design using the red potato variety Sangre.

Each "treatment" was an insect management strategy that included a combination of registered seed treatment, in-furrow, and/ or foliar insecticides. During the growing season, the decision of when and what foliar insecticides (if any) to apply was determined by considering the results of regular insect assessments, plant defoliation, environmental conditions, and pest stage present.

Procedure:

Plot size:	4 rows by 6 m (Assessments conducted on 2 centre rows)
Trial design:	RCB 4 replicates
Location:	Peak of the Market Research Site, Winkler
Soil type:	Reinland Fine Sandy Loam
Crop:	Potatoes
Variety:	Sangre
Row spacing:	38”
Planting date:	May 15
Foliar insecticide app. dates:	Delegate July 7 (Treatment 14) Delegate July 11 (Treatments 1, 9, 10, 11) Delegate July 19 (Treatments 2, 5, 6) Delegate July 24 (Treatment 12) Exirel August 9 (Treatments 1, 3, 4, 7, 9, 11, 12, 13, 14)
Topkill / Harvest dates:	August 31 / September 21
Treatments:	Table 1.

Table 1. List of insecticide treatments.

	At Plant Strategy				Foliar Insecticide
Trt	Product	Method	Group	Rate	Group Options
1	Titan	IF	4	2.0 ml/ 100 m	3 / 5 / 28
2	Titan	IF	4	3.3 ml/ 100 m	3 / 5 / 28
3	Titan	ST	4	10.4 ml/100 kg	3 / 5 / 28
4	Titan	ST	4	20.8 ml/100 kg	3 / 5 / 28
5	Actara	IF	4	3.4 ml/100 m	3 / 5 / 28
6	Actara	IF	4	4.4 ml/100 m	3 / 5 / 28
7	Actara	ST	4	18 ml/100 kg	3 / 5 / 28
8	Actara	ST	4	23.2 ml/100 kg	3 / 5 / 28
9	Verimark	IF	28	6.75 ml/100 m	3 / 5
10	Verimark	IF	28	9 ml/100 m	3 / 5
11	Verimark	ST	28	45 ml/100 kg	3 / 5
12	Minecto Duo	IF	4/28	4.4 g/100 m	3 / 5
13	Minecto Duo	IF	4/28	7.5 g/100 m	3 / 5
14	None (foliar only)	-	-	-	3 / 5 / 28
15	Untreated Check	-	-	-	

Colorado Potato Beetle Population:
The resident population of CPB at the research site provided a high level of pressure for the trial, and the highest population of beetles in the 3 years of conducting this trial.

Insect and Defoliation Assessments:
In-field assessments of the CPB population were done by counting the number of CPB adults; and $1^{st}/2^{nd}$, $3^{rd}/4^{th}$ instar larvae on 10 plants per plot. Assessments began on July 4 and continued weekly until Aug. 16. An estimation of percent defoliation was also conducted, beginning on July 10 and continued until August 16. This trial did not become infested with potato leafhopper or aphids, so no other insect counts or damage were assessed in this year of the trial.

Foliar Insecticide Decisions:
When each weekly CPB and defoliation assessments were completed, the data for each treatment was reviewed to determine if a foliar insecticide was required. No specific threshold for CPB adults and/ or larvae, nor defoliation were applied. Rather, the decision to apply a foliar insecticide was based on the relative population (and insect stage) and/ or defoliation data across the treatments.

The foliar insecticide options were considered and chosen based on:
- The stage of the beetles and weather conditions.
- The insecticide group used as a foliar would not be the same group used as a seed treatment or in-furrow.
- The foliar insecticide group to be rotated accordingly if multiple foliar applications were needed.
- Group 5 insecticides are best targeted to egg hatch or small larvae.
- Group 3 would be used if weather conditions were conducive (synthetic pyrethroids are less effective at high temperatures). Resistance is also known to exist to Group 3 insecticides.

Foliar Application Method

Equipment:	Tractor mounted pneumatic sprayer
Nozzle Type:	Tee-Jet 80-02 Flat Fan
Nozzle Spacing:	50 cm
Nozzle Height:	45 cm
Pressure:	30 psi (207 kPa)
Volume:	225 L/ha

Pest Management
No insecticides were used other than the test substances indicated in the procedure and Table 1. A Gramoxone burn off application was completed on June 8, Prism/ Sencor were applied on June 29. The fungicide program consisted of weekly application of Bravo, with one application of Luna Tranquility for additional early blight control and one application each of Orondis Ultra for late blight protection.

Tuber Yield and Grade
Gross yield was determined at harvest and samples were graded for size profile.

RESULTS

CPB Larvae

Initial CPB counts were made on July 4; larvae data are presented in Tables 2, 3 and 4. Since the patterns are similar with the different larval stages, discussion will refer to the total combined larvae rather than breakdown by instar stages. Delegate was applied to treatment 14 (Foliar only) on July 7 and by the next assessment on July 10, the larvae counts in treatment 14 had declined as a result.

Based on the July 10 assessments, larvae numbers in the Verimark treatments as well as the Titan IF Low Rate were significantly higher than other insecticide treatments, so Delegate was applied to treatments 1, 9, 10, and 11. By July 18 the larvae counts continued to build and treatments 2, 5, 6, and 12 had significantly more larvae than other treatments. In response these treatments were identified to receive an application of Delegate on July 19. However, there was an application error and treatment 12 was not treated until July 24, and this explains why the larvae counts did not drop in treatment 12 by the July 24 assessment. The larvae numbers remained relatively low for the July 24 and 28 assessments, but began to increase again by August 4. Action was not immediately taken due other factors like defoliation and proximity to top kill. However, on August 9 the decision was made to make a foliar application of insecticide to treatments 1, 3, 4, 7, 9,11, 12, 13, and 14. This was the second foliar application to many of these plots, so Exirel was applied. By the August 16 assessment the larvae counts declined in all the treatments that received Exirel, but remained high in others.

Table 2. Effect of insecticide treatment on number of 1st and 2nd instar CPB larvae.

		1st and 2nd CPB Instars (10 Plants)									
	Treatment	4-Jul	7-Jul	10-Jul	14-Jul	18-Jul	24-Jul	28-Jul	4-Aug	9-Aug	16-Aug
1	Titan IF Low Rate	2.9 bc	44.3 abc	41.9 ab	1.8 ef	1.2 c	1.3 c-f	0.6 de	19.1 a	10.3 a	0.0 c
2	Titan IF High Rate	0.2 cd	3.9 e	4.2 d	34.6 abc	36.3 ab	0.9 def	0.2 de	1.8 def	1.8 c-f	1.9 b
3	Titan ST Low Rate	0.0 d	0.0 e	0.0 d	8.2 cde	9.3 b	11.7 a	6.8 ab	8.7 a-d	2.9 b-f	0.0 c
4	Titan ST High Rate	0.0 d	0.0 e	0.0 d	0.4 f	1.6 c	5.4 a-e	5.5 abc	22.5 a	7.7 abc	0.3 c
5	Actara IF Low Rate	0.5 cd	2.4 e	10.7 cd	49.0 ab	37.7 ab	0.1 f	0.0 e	5.8 a-e	5.0 a-d	7.7 a
6	Actara IF High Rate	0.0 d	0.0 e	1.9 d	40.0 ab	47.3 a	0.5 ef	0.4 de	3.6 b-e	4.3 a-d	8.6 a
7	Actara ST Low Rate	0.0 d	0.0 e	3.6 d	7.8 cde	10.4 b	12.9 a	8.6 a	9.9 a-d	1.8 c-f	0.0 c
8	Actara ST High Rate	0.0 d	0.0 e	0.0 d	12.0 bcd	20.4 ab	5.9 a-d	5.7 abc	8.8 a-d	4.6 a-d	2.1 b
9	Verimark IF Low Rate	7.0 ab	28.2 bc	32.5 abc	0.4 f	0.2 c	3.7 a-f	2.1 bcd	18.0 ab	9.0 ab	0.0 c
10	Verimark IF High Rate	3.0 bc	24.3 cd	38.1 ab	1.5 ef	0.8 c	2.0 b-f	1.5 cde	11.1 abc	8.2 ab	0.6 bc
11	Verimark ST	1.8 bcd	25.8 bcd	50.9 ab	2.3 def	1.1 c	2.5 b-f	1.9 bcd	17.0 ab	5.8 abc	0.0 c
12	Minecto Duo IF Low Rate	0.4 cd	5.8 de	24.7 bc	59.3 a	38.6 ab	7.4 abc	0.0 e	0.0 f	0.1 f	0.0 c
13	Minecto Duo IF High Rate	0.0 d	1.2 e	2.3 d	7.1 de	21.9 ab	9.0 ab	1.2 de	2.0 c-f	0.6 def	0.0 c
14	Foliar	21.1 a	75.7 a	4.1 d	1.4 ef	1.1 c	0.3 f	1.2 de	16.6 ab	3.2 a-e	0.2 c
15	Untreated Check	15.8 a	60.4 ab	66.8 a	59.1 a	26.1 ab	7.2 abc	1.2 de	0.7 ef	0.2 ef	0.0 c
CV		112.1	56.5	53.9	46.2	43.1	63.5	73.0	49.5	55.4	105.9
Treatment Prob(F)		0.0001	0.0001	0.0001	0.0001	0.0001	0.0018	0.0001	0.0004	0.0019	0.0001

Means followed by same letter or symbol do not significantly differ (P=.05, LSD)
t: data transformed to stabilize variance. LSD's not presented for transformed data.

Table 3. Effect of insecticide treatment on number of 3rd and 4th instar CPB larvae.

	Treatment	3rd and 4th Instar CPB Instars (10 Plants)																			
		4-Jul		7-Jul		10-Jul		14-Jul		18-Jul		24-Jul		28-Jul		4-Aug		9-Aug		16-Aug	
1	Titan IF Low Rate	0.0	a	3.5	c	67.5	a	3.9	c	1.7	f	5.2	cd	8.5	b-e	15.0	a-d	41.8	a	2.0	b
2	Titan IF High Rate	0.1	a	0.6	d	6.1	bcd	27.4	b	53.7	abc	2.1	cde	1.7	efg	2.4	efg	2.3	de	10.1	a
3	Titan ST Low Rate	0.0	a	0.0	d	0.2	e	1.1	cd	4.7	ef	25.8	ab	18.3	ab	35.7	ab	12.3	bcd	1.1	bc
4	Titan ST High Rate	0.0	a	0.0	d	0.0	e	0.0	d	0.7	f	4.7	cd	7.7	b-f	39.1	ab	26.9	abc	0.8	bc
5	Actara IF Low Rate	0.0	a	0.2	d	6.7	bc	43.4	ab	71.6	ab	1.0	de	0.7	g	8.0	cde	8.9	cde	24.5	a
6	Actara IF High Rate	0.0	a	0.0	d	1.0	de	5.3	c	34.4	bcd	0.3	e	1.3	fg	13.3	a-d	10.0	cde	23.1	a
7	Actara ST Low Rate	0.0	a	0.0	d	0.5	e	2.7	cd	10.1	de	38.9	a	29.6	a	45.9	a	19.2	abc	0.6	bc
8	Actara ST High Rate	0.0	a	0.0	d	0.0	e	1.4	cd	13.8	de	43.1	a	12.8	bc	23.0	abc	19.2	abc	17.3	a
9	Verimark IF Low Rate	0.6	a	7.9	bc	71.3	a	3.0	cd	0.8	f	3.2	cde	7.1	c-f	25.6	abc	29.2	abc	1.3	bc
10	Verimark IF High Rate	0.0	a	4.3	c	41.5	a	2.6	cd	1.3	f	6.1	c	8.4	b-e	10.6	b-e	23.4	abc	25.6	a
11	Verimark ST	0.1	a	3.8	c	40.1	a	3.2	c	1.6	f	5.4	cd	9.9	bcd	26.4	abc	34.9	ab	1.8	bc
12	Minecto Duo IF Low Rate	0.0	a	0.0	d	9.3	b	61.7	ab	88.6	ab	5.8	c	0.3	g	0.3	g	0.2	e	0.0	c
13	Minecto Duo IF High Rate	0.0	a	0.0	d	1.6	cde	3.6	c	18.2	cde	37.3	a	11.6	bc	5.0	def	9.7	cde	0.2	bc
14	Foliar	0.5	a	30.2	a	2.6	b-e	2.3	cd	1.7	f	8.1	bc	2.6	d-g	20.9	a-d	45.7	a	0.8	bc
15	Untreated Check	0.4	a	14.0	ab	87.7	a	137.4	a	168.3	a	48.1	a	10.5	bcd	1.3	fg	2.2	de	1.8	bc
CV		277.7		74.3		46.8		50.4		37.8		38.1		44.3		36.5		50.1		53.8	
Treatment Prob(F)		0.2245		0.0001		0.0001		0.0001		0.0001		0.0001		0.0001		0.0001		0.0003		0.0001	

Table 4. Effect of insecticide treatment on total number of CPB larvae.

	Treatment	Total Larvae (10 Plants)																			
		4-Jul		7-Jul		10-Jul		14-Jan		18-Jul		24-Jul		28-Jul		4-Aug		9-Aug		16-Aug	
1	Titan IF Low Rate	2.9	bcd	48.3	bc	105.9	ab	6.1	ef	3.4	def	6.4	bc	7.7	cde	47.9	abc	50.9	a	2.0	b
2	Titan IF High Rate	0.3	cd	4.5	d	10.1	de	81.9	bc	89.7	ab	3.5	bc	1.9	fg	5.3	efg	5.3	fgh	12.5	a
3	Titan ST Low Rate	0.0	d	0.0	d	0.2	f	14.8	ef	13.2	cde	39.1	a	25.4	ab	47.8	abc	16.0	c-g	1.1	b
4	Titan ST High Rate	0.0	d	0.0	d	0.0	f	0.5	f	2.0	f	9.8	b	12.5	bcd	65.5	a	35.2	a-d	1.1	b
5	Actara IF Low Rate	0.5	cd	2.5	d	17.1	cd	95.5	bc	111.6	ab	1.2	c	0.9	g	15.1	c-g	14.5	d-g	33.6	a
6	Actara IF High Rate	0.0	d	0.0	d	2.0	ef	55.4	cd	84.0	ab	1.2	c	2.4	efg	22.4	b-f	15.3	d-g	35.2	a
7	Actara ST Low Rate	0.0	d	0.0	d	2.3	ef	18.5	de	17.8	cd	52.1	a	39.7	a	65.0	a	21.0	b-f	0.6	b
8	Actara ST High Rate	0.0	d	0.0	d	0.0	f	17.5	e	38.3	bc	48.6	a	18.4	abc	39.3	a-d	24.0	a-e	19.8	a
9	Verimark IF Low Rate	7.6	ab	38.3	bc	104.6	ab	4.0	ef	0.9	f	6.5	bc	8.1	cde	46.6	abc	38.7	a-d	1.3	b
10	Verimark IF High Rate	3.0	bc	31.1	c	76.5	abc	4.9	ef	2.3	ef	7.9	b	9.5	bcd	25.6	a-e	31.7	a-e	26.3	a
11	Verimark ST	2.0	bcd	31.4	c	92.7	ab	6.3	ef	2.7	ef	8.1	b	11.0	bcd	49.8	abc	40.9	abc	1.8	b
12	Minecto Duo IF Low Rate	0.4	cd	5.8	d	29.5	bcd	128.2	b	130.7	ab	81.9	a	0.4	g	0.4	g	0.6	h	0.0	b
13	Minecto Duo IF High Rate	0.0	d	1.2	d	2.7	ef	18.5	de	43.3	bc	46.1	a	12.5	bcd	10.0	d-g	10.9	e-h	0.2	b
14	Foliar	21.4	a	111.8	a	9.5	de	5.1	ef	2.5	ef	8.3	b	4.6	def	52.8	ab	46.0	ab	0.8	b
15	Untreated Check	16.8	a	77.1	ab	148.1	a	231.5	a	206.1	a	55.5	a	9.1	bcd	2.7	fg	3.0	gh	1.8	b
CV		111.7		53.7		41.8		39.9		35.2		32.2		34.1		43.1		37.6		51.2	
Treatment Prob(F)		0.0001		0.0001		0.0001		0.0001		0.0001		0.0001		0.0001		0.0001		0.0001		0.0001	

CPB Adults

The population of resident over-wintering adults at the site was the highest observed in the 3 years of conducting this trial. The spring population provided some early pressure for the trial, and adults continued to be observed into July (Table 5). The reasons for this appear to be the prolonged emergence period of overwintering adults, as well as the presence of summer adults. This resulted in the ever presence of adults within the trial.

Table 5. Effect of insecticide treatment on CPB Adults.

	Treatment	Adults (10 Plants)																			
		4-Jul		7-Jul		10-Jul		14-Jul		18-Jul		24-Jul		28-Jul		4-Aug		9-Aug		16-Aug	
1	Titan IF Low Rate	3.2	abc	3.0	a	1.3	abc	0.0	c	2.7	ab	1.4	a	0.7	bc	6.3	a	5.8	bcd	1.8	fgh
2	Titan IF High Rate	4.8	a	5.0	a	2.7	a	0.1	bc	0.7	bcd	0.2	bc	1.9	b	17.5	a	15.9	abc	9.2	bcd
3	Titan ST Low Rate	3.3	abc	4.0	a	3.1	a	0.7	ab	0.6	bcd	1.4	a	0.7	bc	2.7	a	10.0	a-d	4.6	c-g
4	Titan ST High Rate	1.5	bcd	3.5	a	2.6	ab	1.1	ab	3.7	a	1.7	a	0.6	bc	5.8	a	6.3	bcd	3.9	d-g
5	Actara IF Low Rate	3.3	abc	3.3	a	2.0	ab	0.3	bc	0.6	bcd	0.2	bc	0.2	bc	11.6	a	17.0	abc	13.0	bcd
6	Actara IF High Rate	1.1	cd	4.5	a	2.8	a	0.0	c	0.2	cd	0.4	abc	1.4	bc	4.0	a	5.2	cd	13.7	bc
7	Actara ST Low Rate	3.4	abc	2.3	a	3.5	a	1.1	ab	0.9	bcd	0.0	c	0.0	c	6.2	a	9.9	a-d	8.9	bcd
8	Actara ST High Rate	3.0	abc	2.5	a	1.8	ab	2.1	a	0.6	bcd	0.6	abc	0.6	bc	5.5	a	8.1	a-d	49.3	a
9	Verimark IF Low Rate	1.1	cd	1.8	a	0.3	bc	0.1	bc	2.2	ab	1.4	a	0.3	bc	6.2	a	3.7	cd	2.1	e-h
10	Verimark IF High Rate	3.9	ab	1.3	a	0.3	bc	0.4	bc	2.3	ab	0.2	bc	0.2	bc	9.5	a	4.6	cd	25.3	ab
11	Verimark ST	0.2	d	3.5	a	0.0	c	0.9	ab	1.9	ab	0.4	abc	0.6	bc	3.6	a	5.1	cd	1.6	gh
12	Minecto Duo IF Low Rate	4.6	a	3.8	a	1.8	ab	0.1	bc	1.0	a-d	1.0	ab	0.2	bc	24.7	a	35.1	a	7.6	cde
13	Minecto Duo IF High Rate	5.0	a	4.0	a	4.3	a	0.7	ab	1.0	a-d	0.2	bc	0.4	bc	14.5	a	26.9	ab	8.1	b-e
14	Foliar	1.1	cd	3.3	a	1.1	abc	0.2	bc	1.6	abc	0.6	abc	0.4	bc	6.5	a	1.8	d	0.3	h
15	Untreated Check	0.9	cd	2.3	a	0.9	abc	0.0	c	0.0	d	0.6	abc	8.5	a	23.4	a	14.2	abc	7.1	c-f
CV		32.8		73.1		64.3		104.3		79.9		94.1		119.0		54.4		43.7		37.9	
Treatment Prob(F)		0.0047		0.6766		0.0365		0.0140		0.0332		0.0332		0.0037		0.4843		0.0464		0.0001	

Table 6. Effect of insecticide treatment on foliar defoliation by CPB.

	Treatment	Defoliation (% Leaf Area)															
		10-Jul		14-Jul		18-Jul		24-Jul		28-Jul		4-Aug		9-Aug		16-Aug	
1	Titan IF Low Rate	8.4	ab	14.4	b	17.3	b	16.3	bcd	11.3	cd	14.8	cde	17.5	bcd	21.0	bcd
2	Titan IF High Rate	2.4	bc	6.1	bc	17.9	b	21.3	bc	20.0	bc	25.0	bc	27.0	bc	31.8	b
3	Titan ST Low Rate	0.0	d	0.9	de	2.1	cd	6.8	cd	11.3	cd	15.0	cde	16.5	bcd	18.5	bcd
4	Titan ST High Rate	0.0	d	0.3	e	0.5	d	1.5	d	2.5	d	6.8	e	8.0	d	9.5	d
5	Actara IF Low Rate	2.5	bc	7.6	bc	17.0	b	18.0	bc	18.8	bc	22.5	bcd	21.5	bcd	19.3	bcd
6	Actara IF High Rate	0.6	cd	3.1	cd	8.4	bc	8.0	cd	6.8	cd	8.8	de	8.8	d	14.8	cd
7	Actara ST Low Rate	0.6	cd	3.1	cd	7.5	bcd	13.5	bcd	18.3	bc	18.0	b-e	19.3	bcd	21.3	bcd
8	Actara ST High Rate	0.0	d	0.9	de	3.2	cd	7.8	cd	12.5	cd	15.8	cde	18.0	bcd	23.5	bcd
9	Verimark IF Low Rate	6.8	b	8.6	bc	9.8	bc	10.8	bcd	11.0	cd	14.8	cde	13.5	cd	14.3	d
10	Verimark IF High Rate	7.9	ab	6.7	bc	9.9	bc	10.5	bcd	10.3	cd	12.8	cde	13.3	cd	19.3	bcd
11	Verimark ST	5.9	b	6.3	bc	11.0	bc	13.3	bcd	13.8	bcd	17.5	b-e	18.5	bcd	19.8	bcd
12	Minecto Duo IF Low Rate	4.3	b	9.5	bc	19.5	b	24.0	b	28.8	b	32.5	b	30.8	b	30.0	bc
13	Minecto Duo IF High Rate	0.9	cd	3.1	cd	6.3	bcd	11.3	bcd	15.0	bcd	16.3	cde	17.5	bcd	19.8	bcd
14	Foliar	3.0	bc	6.0	bc	6.8	bcd	7.0	cd	6.8	cd	10.3	cde	13.5	cd	18.8	bcd
15	Untreated Check	23.5	a	41.0	a	55.1	a	61.3	a	64.8	a	75.0	a	85.0	a	95.5	a
CV		57.9		38.6		41.2		68.5		65.0		53.0		48.0		43.6	
Treatment Prob(F)		0.0001		0.0001		0.0001		0.0001		0.0001		0.0001		0.0001		0.0001	

Defoliation

Defoliation in the untreated control reached 23.5% by the July 10 assessment and generally continued to increase until Aug. 16, when defoliation was maximized at 95.5% (Table 6). Defoliation was observed

in most other treatments on July 10, and ranged from 0- 8.4%. Generally, defoliation increased slowly in most treatments over the duration of the trial and in response the CPB population present. Although the insect pressure was very heavy in some treatments, and evidenced by the near to complete defoliation of the untreated check, defoliation did not exceed 31.8% in any of the insecticide treated treatments.

Foliar Application Decisions

As a result of the CPB pressure throughout the season all of the insecticide treatments received at least one foliar insecticide, with the exception of treatment 8 (Actara ST High Rate). Delegate was the first foliar insecticide of choice because of the efficacy and ability to control multiple larval stages. When it became apparent that some treatments would require a second foliar application, Exirel was chosen. Although Exirel contains the same active ingredient as Verimark, which was used as a seed treatment and in-furrow application in some treatments, it was still the preferred option over repeating a foliar application of Delegate on the same plots, or using a synthetic pyrethroid under a high CPB pressure situation.

Table 7. Summary of foliar insecticides applied during this trial.

Date	Treat #		Foliar Insecticide Applied
July 7	14	Foliar ONLY	Delegate
July 11	1	Titan IF Low Rate	Delegate
	9	Verimark IF Low Rate	
	10	Verimark IF High Rate	
	11	Verimark ST	
July 19	2	Titan IF High Rate	Delegate
	5	Actara IF Low Rate	
	6	Actara IF High Rate	
July 24	12*	Minecto Duo IF Low Rate	Delegate
August 9	1**	Titan IF Low Rate	Exirel
	3	Titan ST Low Rate	
	4	Titan ST High Rate	
	7	Actara ST Low Rate	
	9**	Verimark IF Low Rate	
	11**	Verimark ST	
	12**	Minecto Duo IF Low Rate	
	13	Minecto Duo IF High Rate	
	14**	Foliar ONLY	

***Application error, treatment should have occurred on July 19**

****Denotes the second foliar application for these treatments**

Tuber Yield and Grade:
The trial was harvested on Sept. 21 and subsequently graded (Table 8). The untreated control yielded significantly less (165.1 cwt/ac) than all of the insecticide treatments. The poor yield of the untreated control was expected considering the near complete defoliation by August 16. The yield from the insecticide treatments ranged from 307- 372 cwt/ac range. Although there were no significant differences amongst these with respect to yield, it is interesting to note that the three highest yielding treatments (4-Titan ST High Rate, 6-Actara IF High Rate, 9-Verimark IF Low Rate) had the lowest defoliation at the last assessment date. However, there are no clear correlations with the remainder of the treatments.

Table 8. Effect of insecticide strategies on potato yield and grade.

	Treatment	Plus Foliar Insecticide Applied In Season	Yield (cwt/ac) <2"		2-2.25"		2.25-3"		3-3.5"		>3.5"		Total	
1	Titan IF Low Rate	Delegate & Exirel	27.8	a	39.4	a	238.4	ab	25.9	a	6.4	a	337.9	a
2	Titan IF High Rate	Delegate & Exirel	41.2	a	34.0	a	229.6	ab	29.8	a	0.0	a	334.6	a
3	Titan ST Low Rate	Exirel	40.3	a	34.6	a	227.0	ab	41.9	a	2.5	a	346.2	a
4	Titan ST High Rate	Exirel	36.7	a	31.7	a	248.3	ab	51.6	a	3.7	a	371.9	a
5	Actara IF Low Rate	Delegate	30.3	a	37.5	a	241.9	ab	41.0	a	1.8	a	352.4	a
6	Actara IF High Rate	Delegate	30.7	a	42.3	a	234.2	ab	44.6	a	1.9	a	353.7	a
7	Actara ST Low Rate	Exirel	32.4	a	28.9	a	239.4	ab	21.1	a	0.0	a	321.8	a
8	Actara ST High Rate		39.8	a	41.1	a	222.8	ab	21.8	a	0.0	a	325.5	a
9	Verimark IF Low Rate	Delegate & Exirel	29.3	a	32.3	a	255.9	a	37.4	a	2.1	a	357.0	a
10	Verimark IF High Rate	Delegate	37.4	a	41.7	a	194.9	b	37.9	a	0.0	a	311.9	a
11	Verimark ST	Delegate & Exirel	30.3	a	34.5	a	205.2	ab	53.3	a	10.2	a	333.5	a
12	Minecto Duo IF Low Rate	Delegate & Exirel	36.9	a	38.9	a	200.1	ab	34.8	a	4.2	a	314.8	a
13	Minecto Duo IF High Rate	Exirel	28.2	a	35.5	a	226.4	ab	16.9	a	0.0	a	306.9	a
14	Foliar ONLY	Delegate & Exirel	33.3	a	30.2	a	215.8	ab	55.8	a	6.5	a	341.5	a
15	Untreated Check		40.3	a	31.8	a	89.6	c	3.5	a	0.0	a	165.1	b
LSD P=.05			ns		16.8		56.7		ns		ns		77.7	
CV			29.3		33.1		18.2		78.3		261.3		16.7	
Treatment Prob(F)			0.5501		0.8988		0.0003		0.3228		0.6453		0.0023	

CONCLUSIONS
Most strategies (treatments) included in this trial had either a seed treatment or in-furrow applied insecticide and they provided good early season control of CPB. However, by July 10 all treatments with Verimark, as well as the Titan IF Low Rate had significantly more CPB larvae compared to most treatments that contained a neonicotinoid insecticide. As the season progressed, additional strategies required one or two foliar insecticide treatments to control CPB and manage the level of defoliation.

The high population of CPB during 2017 resulted in near complete defoliation (95.5%) of the untreated control by August 16. All strategies that received one or more insecticide application(s) maintained defoliation below 32%, and there were no significant differences in yield amongst these treatments, but they all yielded significantly higher than the untreated control.

The results obtained in this trial were achieved by employing a variety of different insecticide strategies, but the following trends emerged:

- Verimark as a seed treatment or in-furrow applied insecticide does not provide long season control of CPB. In 3 years of this trial, the Verimark treatments resulted in increased levels of CPB larvae by early to mid-July compared to all other systematic insecticide treatments.
- Control of CPB using neonicotinoid insecticides is rate dependent. Lower rates of the same product results in shorter duration of control, and conversely higher rates generally provide longer duration of control.
- Seed treatment application methods generally provide longer duration of control compared to in-furrow applications of the same insecticide, but are also rate dependent as previously explained.

Delegate was used as the first foliar insecticide option as needed, and significantly reduced the number of CPB larvae once again demonstrating the effectiveness of this insecticide. These results are consistent with the two previous years of the trial. When additional foliar applications were required in 2017, Exirel was applied and very good results were achieved. The poor performance of this same active ingredient as a seed treatment or in-furrow application (Verimark) suggests that the method of application may be the reason for the less than desired performance as a systemic product rather than the activity of this chemistry on CPB.

One objective of this trial was to assess the economics of the different insect management strategies. It is clear from the results that each strategy has to be assessed on its performance, i.e. the value of the crop produced and compared to the input costs of the CPB management strategy, which varied greatly in this trial. The yields were not significantly different amongst the insecticide strategies, but the input costs varied greatly. For example, a strategy that included a seed treatment or in-furrow plus two foliar insecticide applications did not yield significantly more than a seed treatment only; nor a foliar program with two applications. For these reasons, it is important that pest management decision makers consider the results of this trial with respect to insecticide performance, rate response, and application method to develop a strategy that will maximize their economic return for the type of potato being produced.

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