EVALUATION OF INSECTICIDES AND INSECTICIDE USE PATTERNS FOR MANAGEMENT OF THRIPS AND IRIS YELLOW SPOT VIRUS

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Overview

Onion thrips and the iris yellow spot virus that these thrips vector are major limiting factors for onion production in the Treasure Valley. There are about 20,000 acres of onions produced within a 50-mile radius of Ontario, Oregon. This high concentration of onions creates unique production challenges, especially for onion thrips and iris yellow spot virus management. Thrips can rapidly develop resistance to insecticides, and new insecticides may rapidly lose their effectiveness. Therefore, it is important to assess the effectiveness of currently registered insecticides and to develop alternative management methods as part of an overall integrated pest management (IPM) program.

We conducted two field experiments to evaluate different insecticide management programs, with products applied in various sequences over the growing season. One trial consisted of 18 different treatment regimes, with products applied by foliar application. The second trial was designed to compare treatment regimens where products were applied by drip application or by foliar application.

Trial 1: Foliar Insecticide Trial Materials and Methods

Cultural practices

Onions were grown in 2014 on an Owyhee silt loam. The field had been planted to wheat in 2013. In the fall of 2013, the wheat stubble was shredded and the field was irrigated. The field was then disked, moldboard plowed, and groundhogged. A soil analysis taken in the fall of 2013 showed a pH of 7.9, 1.27% organic matter, 181% base saturation, 21 ppm of phosphorus, 418 ppm of potassium, and less than 1.5% lime. Based on the soil analysis, 500 lb of sulfur/acre, 3 lb of manganese/acre, and 1 lb of boron/acre were broadcast before plowing. Phosphorus was intentionally not added in the fall. After plowing, the field was fumigated with Vapam® at 15 gal/acre and bedded at 22 inches.

Seed was planted on March 18 in double rows spaced 3 inches apart at 9 seeds/ft of single row. Each double row was planted on beds spaced 22 inches apart. Planting was done with customized John Deere Flexi Planter units equipped with disc openers. Immediately after

planting, the onions received a narrow band of Lorsban® 15G at 3.7 oz/1,000 ft of row (0.82 lb ai/acre) over the planted rows, and the soil surface was rolled. Onion emergence started on April 7.

All onions in these trials were grown under drip irrigation. The field had drip tape laid at 4-inch depth between 2 onion beds during planting. Drip tape (Toro Aqua-Traxx, Toro Co., El Cajon, CA) with emitters spaced 12 inches apart and an emitter flow rate of 0.22 gal/minute/100 ft was laid at 4-inch depth between 2 onion beds at the time of planting. The distance between the tape and the center of each bed was 11 inches. The water application rate was 0.06 inch/hour.

The field was irrigated as necessary to maintain soil water tension at 20 cb at 8-inch depth. Soil water tension was monitored by six granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co. Inc., Riverside, CA) centered at 8-inch depth below the onion row. The sensors were automatically read three times a day with an AM-400 meter (Mike Hansen Co., East Wenatchee, WA).

Insecticide applications

Insecticides were applied weekly beginning May 28, according to the schedule and rates listed in Tables 1 and 2. Five experimental treatments were compared to an untreated check treatment and a standard insecticide treatment. Insecticides were applied with a CO_2 backpack sprayer using a 4-nozzle boom with 11004 nozzles at 30 psi and 35 gal/acre.

Data collection

Weekly thrips counts were made, starting on May 23 (before applications began). Thrips counts were made by counting the number of thrips on 10 consecutive plants in one of the middle 2 rows of each plot. Adult and larval (immature) thrips were counted separately. Each treatment plot was 4 double rows wide by 23 ft long.

Onions in each plot were evaluated subjectively for severity of symptoms of iris yellow spot virus (IYSV) and thrips feeding damage on August 8. Ten consecutive plants in one of the middle 2 rows of each plot were rated on a scale of 0 to 4 of increasing severity of symptoms or feeding damage. Separate ratings were made for the inner, middle, and outer leaves of each plant to estimate damage occurrence over the course of the growing season.

The rating scale was as follows:

Rating	IYSV lesions (% foliage with lesions)	Feeding damage (% foliage with scarring)
0	0	0
1	1-25	1-25
2	26-50	26-50
3	51-75	51-75
4	76-100	76-100

The onions were lifted on September 10 to field cure. Onions from the middle two double rows in each plot were topped by hand and bagged on September 19 and placed in storage. The onions from each plot were graded on October 8 and 9. During grading, bulbs were separated according to quality: bulbs without blemishes (No. 1s), split bulbs (No. 2s), neck rot (bulbs

infected with the fungus *Botrytis allii* in the neck or side), plate rot (bulbs infected with the fungus *Fusarium oxysporum*), and black mold (bulbs infected with the fungus *Aspergillus niger*). The No. 1 bulbs were graded according to diameter: small, medium, jumbo, colossal, and supercolossal. Bulb counts per 50 lb of supercolossal onions were determined for each plot of every variety by weighing and counting all supercolossal bulbs during grading. Marketable yield consisted of No.1 bulbs in the medium or larger size classes (larger than 2¼ inches).

Results and Discussion

Temperatures were warmer throughout the growing season in 2014 than the 30-year historic averages (Fig. 1). The warm early spring temperatures likely contributed to an early buildup of thrips populations.

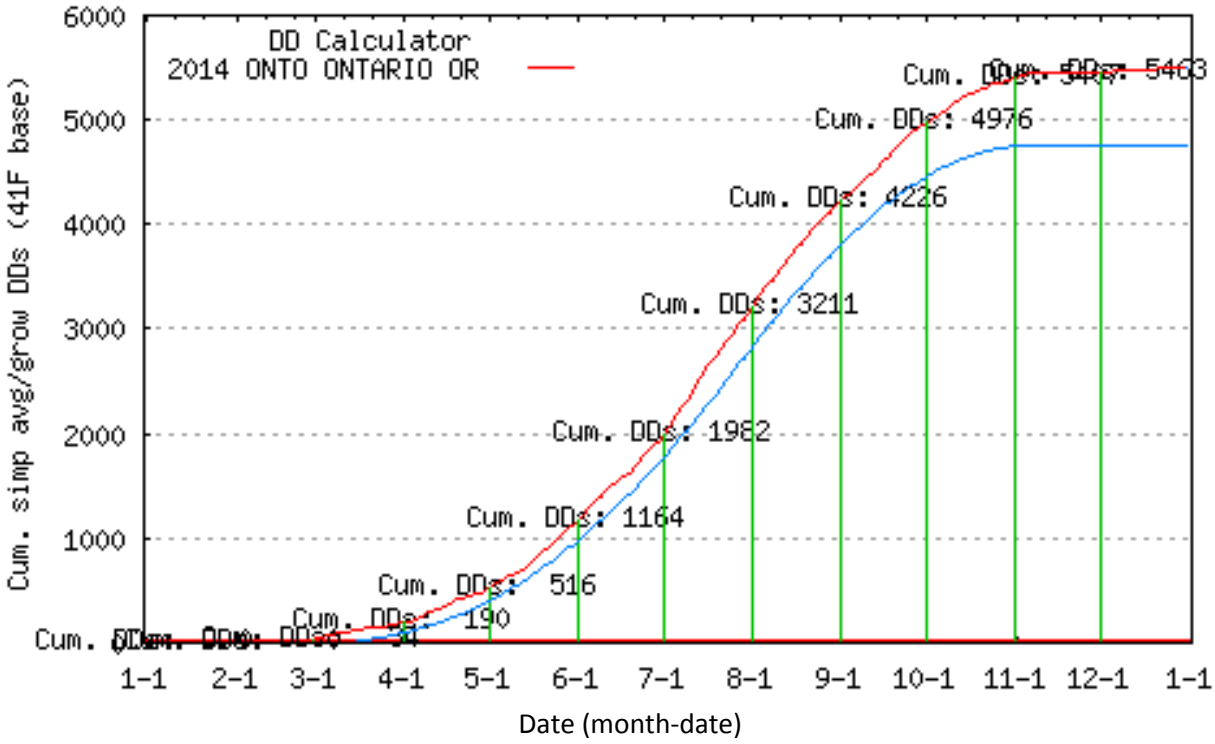

Figure 1. Comparison of the accumulated degree-days for 2014 versus the 30-year average, as recorded at Ontario, OR. The upper line represents the 2014 degree-days (base 50°F), and the lower line represents the historic averages.

Treatments began when thrips populations were approximately four adults per plant and few larvae were present.

Movento® was more effective than in the 2013 trials because applications began when thrips populations were low and the material had time to build up to effective levels in the plant (e.g., Treatments 2, 11-14, 16). There appeared to be a residual effect after the second application of Movento was made, as those treatments tended to have lower thrips counts, especially of immatures for 1-2 additional weeks.

Agri-Mek® performed well in treatments where it used mid-season (applications 2-4: e.g., Treatments 2, 4, 12).

Radiant® and Lannate® generally worked well throughout the season. However, Radiant was generally more effective than Lannate when thrips populations were the greatest.

The combination mix of Aza-Direct® and M-Pede® did not show an effect on thrips abundance; however, treatment programs with these products had some of the highest yields.

The season-long program where combinations of Requiem® and other standard insecticides (Movento, Agri-Mek, Radiant, and Lannate) were used (Treatment 14) had among the lowest season-long thrips totals but not significantly different from the standard program (Treatment 2).

Gladiator® (mixture of abamectin and zeta-cypermethrin) (Treatments 15 and 16), which is not registered for use on onions, was effective in managing thrips.

We used PureSpray™ Green as an adjuvant substitute and to see if the product would have insecticidal effects on thrips. At the 0.5-gal/acre rate, it helped provide thrips control with other insecticides and lead to relatively high yields. Additional research will help determine its utility in a thrips management program.

Onion bulb yield was significantly affected by thrips pressure. Increasing thrips abundance decreased total marketable yield. Treatment 5 was the best yielding treatment but did not necessarily have the best thrips management. Season-long management of thrips is important, but management programs that provided the best management mid-season (late June to early July) tended to produce the best yields (e.g., Treatments 2-5, 10, 16).

Table 1. Insecticide sequences treatments tested for efficacy against onion thrips and iris yellow spot virus. Malheur Experiment Station, Oregon State University, Ontario, OR, 2014. Continued on next page.

Application Date	5/28	6/4	6/11	6/18	6/25	7/2	7/10	7/17
				Application number				
Treatment	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	Control	-	-	-	-	-	-	-
2	Movento	Movento	Agri-Mek	Agri-Mek	Radiant	Radiant	Lannate	Lannate
3	M-Pede + Aza-Direct	M-Pede + Aza-Direct	Movento	Movento	Lannate	Lannate	Radiant + M-Pede	Radiant + M-Pede
4	M-Pede + Aza-Direct	M-Pede + Aza-Direct	Movento	Movento	Agri-Mek	Agri-Mek	Radiant	Radiant
5	M-Pede + Aza-Direct	Movento + Aza-Direct	Movento	Lannate		Radiant + M-Pede		Radiant + M-Pede
6	Movento + Pure Spray Green 0.25	Movento + Pure Spray Green 0.25	Agri-Mek + Pure Spray Green 0.25	Agri-Mek + Pure Spray Green 0.25	Radiant + Pure Spray Green 0.25	Radiant + Pure Spray Green 0.25	Lannate + Pure Spray Green 0.25	Lannate + Pure Spray Green 0.25
7	Movento + Pure Spray Green 0.5	Movento + Pure Spray Green 0.5	Agri-Mek + Pure Spray Green 0.5	Agri-Mek + Pure Spray Green 0.5	Radiant + Pure Spray Green 0.5	Radiant + Pure Spray Green 0.5	Lannate + Pure Spray Green 0.5	Lannate + Pure Spray Green 0.5
8	Movento + Pure Spray Green 1.0	Movento + Pure Spray Green 1.0	Agri-Mek + Pure Spray Green 1.0	Agri-Mek + Pure Spray Green 1.0	Radiant + Pure Spray Green 1.0	Radiant + Pure Spray Green 1.0	Lannate + Pure Spray Green 1.0	Lannate + Pure Spray Green 1.0

Table 1. Continued. Insecticide sequences treatments tested for efficacy against onion thrips and iris yellow spot virus. Malheur Experiment Station, Oregon State University, Ontario, OR, 2014.

Application Date	**5/28**	**6/4**	**6/11**	**6/18**	**6/25**	**7/2**	**7/10**	**7/17**
				Application number				
Treatment	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
9	Movento + Pure Spray Green 0.25	Movento + Pure Spray Green 0.25	Agri-Mek + Pure Spray Green 0.25	Agri-Mek + Pure Spray Green 0.25	Radiant + Pure Spray Green 0.25	Pure Spray Green 1.0	Lannate + Pure Spray Green 0.25	Pure Spray Green 1.0
10	Radiant	Radiant	Movento	Movento	Lannate	Lannate	Lannate	Agri-Mek
11	Movento	Movento	Radiant	Radiant	Lannate	Lannate	Lannate	Agri-Mek
12	Movento + Requiem	Movento + Requiem	Agri-Mek	Agri-Mek	Radiant	Radiant	Lannate	Lannate
13	Movento + Requiem (No MSO)	Movento + Requiem (No MSO)	Agri-Mek	Agri-Mek	Radiant	Radiant	Lannate	Lannate
14	Movento + Requiem	Movento + Requiem	Agri-Mek + Requiem	Agri-Mek + Requiem	Radiant + Requiem	Radiant + Requiem	Lannate + Requiem	Lannate + Requiem
15	Gladiator	Gladiator	Gladiator	Gladiator	Gladiator	Gladiator	Gladiator	Gladiator
16	Movento	Movento	Gladiator	Gladiator	Radiant	Radiant	Lannate	Lannate
17	Movento + Lannate	Movento + Lannate	Agri-Mek	Agri-Mek	Radiant	Radiant	Lannate	Lannate
18	Movento + Lannate	Movento	Agri-Mek	Agri-Mek	Radiant	Radiant	Lannate	Lannate

Table 2. Characteristics of insecticides tested in 18 foliar treatments for efficacy against onion thrips. Malheur Experiment Station, Oregon State University, Ontario, OR, 2014.

NOT ALL INSECTICIDES USED IN THESE TRIALS ARE CURRENTLY REGISTERED FOR USE ON ONIONS. PLEASE CONSULT THE LABEL TO DETERMINE APPROPRIATE USES.

Product	Company	Rate (product per acre)	Adjuvant	Active ingredient	Mode of action group
Agri-Mek SC	Syngenta	3.5 fl oz	MSO 0.5% v/v	Abamectin	6
Aza-Direct	Gowan	12 fl oz	-	Azadirachtin	unknown
Gladiator	FMC	19 fl oz	MSO 0.5% v:v	Zeta-Cypermethrin Abamectin	3A and 6
Lannate LV	DuPont	3 pt	Preference 0.25% v/v	Methomyl	1A
M-Pede	Gowan	5.6 pt	-	Potassium salts of fatty acids	unknown
Movento	Bayer	5 fl oz	MSO 0.5% v/v	Spirotetramat	23
Pure Spray Green	PetroCanada	0.25-1.0 gal	None	Refined oil	unknown
Radiant	Dow	8 fl oz	Dyne-Amic 3.75% v/v	Spinetoram	5
Requiem EC	Bayer	3 qt (Trt 12, 13) 1 qt (Trt 14)		Synthetic terpenes derived from *Chenopodium ambrosioides*	unknown

Table 3. Mean numbers of thrips (total) per onion plant listed by sampling date in response to 18 foliar insecticide regimes. Insecticide applications were made weekly, beginning on May 28 and concluding on July 17. Means on each sample date marked with the same letter are not significantly different. Malheur Experiment Station, Oregon State University, Ontario, OR, 2014.

	Rating Date															
Treatment	6/2		6/9		6/16		6/23		6/30		7/7		7/14		7/21	
number	---------- mean total thrips/plant ----------															
1	2.1	a	25.5	ab	61.6	a	120.7	a	97.3	a	134.2	ab	107.5	a	44.0	abc
2	2.7	a	14.1	bcd	11.6	ef	20.6	efg	16.6	cd	55.6	c-f	115.2	a	46.7	abc
3	2.4	a	20.6	a-d	41.2	ab	56.3	bc	22.1	cd	42.0	def	90.5	ab	18.6	c
4	2.6	a	35.9	a	56.0	a	61.9	b	22.7	cd	36.5	ef	34.6	b	22.6	c
5	3.5	a	18.8	a-d	24.0	bcd	14.9	gh	15.8	cd	47.4	c-f	113.1	a	34.3	abc
6	2.2	a	25.3	ab	39.6	ab	39.6	bcd	31.2	bc	65.7	b-f	119.2	a	35.0	abc
7	1.9	a	18.7	a-d	19.9	cde	32.1	cde	36.0	bc	81.9	b-e	116.4	a	45.7	abc
8	2.5	a	23.9	abc	20.4	cde	26.7	def	37.1	bc	93.8	bcd	94.0	ab	40.2	abc
9	3.4	a	31.8	a	45.4	ab	48.1	bcd	58.9	ab	184.4	a	91.3	ab	41.0	abc
10	1.8	a	19.4	a-d	35.6	abc	38.6	bcd	19.5	cd	32.9	f	55.7	ab	40.8	abc
11	2.3	a	13.7	bcd	8.2	fg	10.4	h	24.1	cd	106.8	abc	132.7	a	43.8	abc
12	2.5	a	13.3	bcd	10.2	f	14.3	gh	16.5	cd	69.5	b-f	129.9	a	38.9	abc
13	1.2	a	10.6	cd	9.4	f	9.5	h	17.1	cd	48.7	c-f	106.9	a	54.3	ab
14	3.4	a	16.6	a-d	9.3	f	16.6	fgh	34.6	bc	79.6	b-e	112.2	a	68.7	a
15	0.7	a	10.1	d	7.4	fg	41.4	bcd	30.7	bc	48.5	c-f	86.8	ab	29.4	bc
16	2.8	a	13.5	bcd	4.5	g	6.0	i	9.4	d	58.0	c-f	123.9	a	38.9	abc
17	0.9	a	14.4	bcd	40.8	ab	28.3	def	17.7	cd	39.9	ef	91.6	ab	30.0	bc
18	0.7	a	11.2	bcd	13.9	def	19.2	efg	16.4	cd	39.3	ef	93.6	ab	45.2	abc

Table 4. Mean numbers of adult thrips per onion plant listed by sampling date in response to 18 foliar insecticide regimes. Insecticide applications were made weekly, beginning on May 28 and concluding on July 17. Means on each sample date marked with the same letter are not significantly different. Malheur Experiment Station, Oregon State University, Ontario, OR, 2014.

	Rating Date															
Treatment	6/2		6/9		6/16		6/23		6/30		7/7		7/14		7/21	
number	---------- mean adult total thrips/plant ----------															
1	2.1	ab	10.4	a	7.6	ab	12.9	ab	16.8	abc	13.3	de	6.9	bc	1.9	a
2	1.3	ab	11.3	a	8.1	ab	12.6	ab	10.3	abc	15.2	cde	10.8	ab	2.6	a
3	1.9	ab	11.4	a	7.4	ab	8.0	abc	21.5	ab	40.1	a	8.3	abc	1.8	a
4	1.8	ab	10.7	a	6.8	abc	10.4	abc	22.1	a	33.2	ab	12.8	ab	2.0	a
5	2.4	a	9.8	a	10.2	ab	12.6	ab	16.2	abc	18.2	cde	10.0	ab	1.1	a
6	2.0	ab	10.1	a	8.3	ab	13.5	ab	11.4	abc	20.3	cde	8.6	abc	3.5	a
7	1.3	ab	8.8	a	6.1	abc	14.7	a	16.6	abc	20.3	cde	10.5	ab	3.0	a
8	1.5	ab	9.4	a	6.8	abc	13.4	ab	17.7	abc	15.3	cde	9.0	abc	2.4	a
9	2.0	ab	11.1	a	9.5	ab	13.9	a	17.0	abc	22.8	bcd	8.2	abc	5.1	a
10	1.4	ab	11.2	a	10.1	ab	9.7	abc	19.4	abc	25.1	bc	18.0	a	3.8	a
11	2.0	ab	11.4	a	7.0	abc	8.9	abc	14.9	abc	19.3	cde	6.6	bc	2.4	a
12	1.9	ab	13.8	a	9.6	ab	12.7	ab	11.9	abc	13.9	de	11.6	ab	1.9	a
13	0.7	b	10.6	a	8.3	ab	8.6	abc	9.4	bc	12.3	e	13.5	ab	2.0	a
14	2.1	ab	9.5	a	8.0	ab	14.2	a	14.6	abc	12.5	e	16.4	a	3.1	a
15	0.6	b	8.7	a	4.4	bc	8.8	abc	9.9	abc	13.2	de	4.3	c	2.4	a
16	1.3	ab	12.4	a	3.4	c	6.5	bc	9.0	c	13.9	de	14.6	ab	1.7	a
17	1.1	ab	10.9	a	10.3	ab	5.8	c	13.6	abc	37.1	a	14.2	ab	2.1	a
18	0.9	ab	10.6	a	12.2	a	13.1	ab	11.3	abc	12.6	e	9.2	abc	2.1	a

Table 5. Mean numbers of larval thrips per onion plant listed by sampling date in response to 18 foliar insecticide regimes. Insecticide applications were made weekly, beginning on May 28 and concluding on July 17. Means on each sample date marked with the same letter are not significantly different. Malheur Experiment Station, Oregon State University, Ontario, OR, 2014.

	Rating Date														
Treatment	6/2		6/9		6/16		6/23		6/30		7/7		7/14		7/21	
number	---------- mean larval thrips/plant ----------															
1	1.3	a	11.1	ab	50.7	a	106.5	a	79.7	a	118.4	ab	84.4	a	41.4	a-d
2	4.3	a	2.1	c-g	2.3	d	8.9	de	6.0	cde	33.9	bc	92.2	a	43.1	abc
3	1.2	a	6.6	a-e	30.3	a	48.9	ab	0.9	ef	1.1	d	65.6	ab	16.2	d
4	2.6	a	19.9	a	46.1	a	51.2	ab	2.0	def	2.4	d	17.5	c	19.2	cd
5	3.2	a	5.6	a-f	12.7	bc	2.8	fg	0.3	f	22.0	c	92.9	a	32.6	a-d
6	0.9	a	9.4	abc	27.4	ab	25.8	bc	17.8	bc	40.2	bc	98.9	a	29.4	bcd
7	2.3	a	7.6	a-d	10.6	c	15.4	cd	18.5	bc	54.9	abc	92.6	a	41.3	a-d
8	2.8	a	11.6	ab	11.5	c	12.2	cde	14.8	bc	74.6	abc	74.5	ab	36.3	a-d
9	5.1	a	14.8	a	32.5	a	33.0	bc	37.9	ab	156.3	a	72.7	ab	34.5	a-d
10	1.8	a	5.4	a-f	22.3	abc	26.8	bc	1.7	def	4.7	d	29.5	bc	35.1	a-d
11	1.2	a	1.8	d-g	0.8	d	2.1	fg	6.9	cd	76.6	abc	108.8	a	40.0	a-d
12	2.5	a	0.5	g	0.5	d	2.6	fg	4.4	cde	50.8	abc	97.2	a	35.6	a-d
13	1.3	a	0.4	g	0.7	d	1.9	fg	6.9	cd	31.7	c	76.5	ab	50.2	ab
14	3.6	a	5.2	a-f	1.0	d	2.5	fg	18.2	bc	59.9	abc	81.2	ab	63.6	a
15	0.5	a	1.1	fg	1.8	d	32.4	bc	18.9	bc	31.6	c	75.2	ab	26.0	bcd
16	3.6	a	1.3	efg	1.0	d	0.6	g	1.3	def	35.4	bc	99.4	a	35.9	a-d
17	0.2	a	2.9	b-g	24.7	abc	20.8	bcd	3.4	def	1.4	d	58.5	ab	26.0	bcd
18	0.1	a	1.0	fg	1.2	d	5.4	ef	3.1	def	22.1	c	67.8	ab	41.4	a-d

Table 6. Visual damage ratings for thrips feeding damage and iris yellow spot virus (IYSV) severity in response to 18 foliar insecticide regimes. Data represent the mean damage ratings (0-4 scale) of 10 plants per plot. Separate ratings were made on the outer, middle, and inner leaves of the same plants per plot. Ratings were done on 8 August. Means marked with the same letter are not significantly different. Malheur Experiment Station, Oregon State University, Ontario, OR, 2014.

Treatment number	IYSV - inner		IYSV - middle		IYSV - outer		Thrips - inner		Thrips - middle		Thrips - outer	
1	1.9	a	2.0	a	1.9	a	2.9	a	2.7	a	2.7	a
2	1.7	a	2.2	a	1.9	a	2.4	ab	2.4	a	2.4	a
3	1.8	a	1.9	a	1.8	a	2.2	ab	2.6	a	2.4	a
4	1.8	a	2.0	a	1.9	a	2.1	b	2.3	a	2.2	a
5	1.9	a	1.7	a	1.8	a	2.4	ab	2.5	a	2.2	a
6	1.9	a	2.1	a	1.9	a	2.6	ab	2.6	a	2.5	a
7	1.8	a	1.9	a	2.0	a	2.4	ab	2.4	a	2.4	a
8	1.7	a	1.9	a	1.6	a	2.6	ab	2.7	a	2.3	a
9	2.1	a	2.1	a	1.7	a	2.7	ab	2.8	a	2.6	a
10	2.1	a	2.1	a	2.1	a	2.2		2.1		2.2	a
11	1.9	a	2.0	a	1.7	a	2.8	a	2.6	a	2.2	a
12	1.7	a	1.9	a	1.5	a	2.5	ab	2.5	a	2.2	a
13	2.0	a	1.8	a	1.7	a	2.5	ab	2.6	a	2.4	a
14	1.9	a	1.9	a	1.7	a	2.4	ab	2.6	a	2.1	a
15	1.6	a	1.3	a	1.5	a	2.4	ab	2.2	a	2.4	a
16	1.8	a	1.7	a	1.8	a	2.5	ab	2.3	a	2.5	a
17	2.0	a	1.8	a	1.6	a	2.7	ab	2.5	a	2.3	a
18	2.1	a	2.0	a	1.9	a	2.5	ab	2.4	a	2.7	a

Table 7. Onion yield in response to 18 foliar-applied insecticide regimes. Data are the mean number of hundredweight per acre (cwt/acre) for the different yield categories. Means marked with the same letter are not significantly different. Malheur Experiment Station, Oregon State University, Ontario, OR, 2014.

Treatment	Small		Medium		Jumbo		Colossal		Supercolossal		Marketable yield		Total yield	
number	cwt/acre													
1	7.035	a	43.254	a	543.048	a	101.650	a	0.000	b	690.363	c	698.055	c
2	2.627	a	17.553	a	383.238	a	320.350	a	50.618	ab	779.383	abc	782.433	abc
3	4.932	a	18.098	a	464.435	a	256.378	a	15.029	ab	764.093	abc	769.443	abc
4	8.181	a	28.456	a	577.553	a	302.970	a	28.407	ab	938.860	ab	948.028	ab
5	3.844	a	13.321	a	576.443	a	330.110	a	50.644	ab	976.128	a	980.545	a
6	6.604	a	13.645	a	460.198	a	279.493	a	16.415	ab	774.450	abc	781.243	abc
7	4.380	a	31.584	a	622.388	a	234.658	a	18.136	ab	913.575	abc	918.303	abc
8	3.461	a	15.283	a	534.913	a	287.965	a	25.610	ab	867.605	abc	871.533	abc
9	10.361	a	34.126	a	531.375	a	149.353	a	5.700	ab	725.070	bc	736.305	bc
10	5.911	a	20.562	a	507.485	a	317.483	a	22.507	ab	876.078	abc	882.300	abc
11	5.001	a	25.388	a	619.338	a	209.348	a	16.819	ab	872.563	abc	877.730	abc
12	4.252	a	22.901	a	570.010	a	302.633	a	9.263	ab	907.923	abc	912.698	abc
13	6.834	a	33.273	a	550.693	a	211.648	a	3.903	ab	809.318	abc	818.510	abc
14	5.616	a	18.866	a	542.043	a	264.018	a	12.232	ab	842.350	abc	848.600	abc
15	3.361	a	17.308	a	442.973	a	427.453	a	68.509	a	960.940	ab	964.480	ab
16	4.025	a	25.311	a	522.955	a	327.270	a	31.955	ab	918.690	abc	924.165	abc
17	7.183	a	26.742	a	578.765	a	273.425	a	10.503	ab	897.873	abc	906.240	abc
18	5.792	a	19.798	a	547.128	a	247.595	a	21.733	ab	860.013	abc	867.010	abc

Trial 2: Drip Insecticide Trial
Materials and Methods

Cultural practices

Cultural practices were the same as in described in the foliar application trial above.

Insecticide applications

Insecticides were applied weekly beginning May 27, according to the schedule and rates listed in Tables 8 and 9. Drip applications were made by injecting appropriate amounts of the product over a 2-hour period. Injections began ~30 min after irrigation started. Irrigation continued for 4-6 hours after the end of the injection. Foliar-applied insecticides were applied with a CO_2 backpack sprayer using a 4-nozzle boom with 11004 nozzles at 30 psi and 35 gal/acre. Applications were made on a 10-day interval, and 6 total applications were made in this trial.

Data collection

Thrips counts were made starting on May 23 (before applications began). After applications began, counts were made 4-6 days after an application. Thrips counts were made by counting the number of thrips on 10 consecutive plants in one of the middle 2 rows of each plot. Adult and larval (immature) thrips were counted separately. Each treatment plot was 4 double rows wide by 23 ft long.

Onions in each plot were evaluated subjectively for severity of symptoms of iris yellow spot virus (IYSV) and thrips feeding damage on August 8. Ten consecutive plants in one of the middle 2 rows of each plot were rated on a scale of 0 to 4 of increasing severity of symptoms or feeding damage. Separate ratings were made for the inner, middle and outer leaves of each plant to estimate damage occurrence over the course of the growing season.

The rating scale was the same as described in the foliar application trial above.

The onions were lifted on September 10 to field cure. Onions from the middle two double rows in each plot were topped by hand and bagged on September 19 and placed in storage. The onions from each plot were graded on October 8 and 9. During grading, bulbs were separated according to quality: bulbs without blemishes (No. 1s), split bulbs (No. 2s), neck rot (bulbs infected with the fungus *Botrytis allii* in the neck or side), plate rot (bulbs infected with the fungus *Fusarium oxysporum*), and black mold (bulbs infected with the fungus *Aspergillus niger*). The No. 1 bulbs were graded according to diameter: small, medium, jumbo, colossal, and supercolossal. Bulb counts per 50 lb of supercolossal onions were determined for each plot by weighing and counting all supercolossal bulbs during grading. Marketable yield consisted of No.1 bulbs in the medium or larger size classes (larger than 2¼ inches).

Results and Discussion

This was the first year of drip-application trials and results should be interpreted cautiously until more data are available. There were few differences in thrips counts among the treatments (Tables 10-12). Vydate applied through the drip was not effective in reducing thrips numbers.

Lannate was used in most treatment programs in the middle of the season (e.g., applications 3 and 4). In those cases, foliar applied Lannate was more effective than drip applied Vydate.

We did not see improved control with the higher rate of Verimark compared with the low rate. There was no difference in thrips control between drip applied Verimark and its foliar-applied counterpart Exirel.

As with the foliar application trial, early season foliar applications of Movento provided control of thrips, with most of the effect seen on numbers of immatures. Movento provided residual control as populations remained low for up to 2 sampling periods (~3 weeks) after the second Movento application. Radiant also demonstrated effectiveness late season in reducing adult and overall thrips numbers. The lack of its effect on larvae late season may stem from a carry-over effect from the high numbers of adults remaining from the preceding applications.

There were no significant differences among damage ratings for the different treatment programs (Table 13).

There were no significant differences in yields among the eight different treatments (Table 14). Although not statistically different, treatment 7, which represented a "foliar standard" had approximately a 40-108% greater amount of colossal bulbs compared to the other treatment programs.

Although the drip applications did not improve thrips control, drip applications may provide benefits in terms of reduced application costs. Newer products, such as ones containing cyazapyr, may ultimately be useful for inclusion in insecticide resistance management programs.

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Table 8. Insecticide treatment sequences tested for efficacy against onion thrips and Iris yellow spot virus. Malheur Experiment Station, Oregon State University, Ontario, OR, 2014. Applications were made by drip (D) or foliar (F) application.

Application date	5/27	6/6	6/16	6/25	7/7	7/17
			Application number			
Treatment	**1**	**2**	**3**	**4**	**5**	**6**
1	Control	-	-	-	-	-
2	Vydate (D)	Vydate (D)	Vydate (D)	Vydate (D)	Radiant (F)	Radiant (F)
3	Verimark (D) 6.75 oz	Verimark (D) 6.75 oz	Lannate (F)	Lannate (F)	Radiant (F)	Radiant (F)
4	Verimark (D) 10.3 oz	Verimark (D) 10.3 oz	Lannate (F)	Lannate (F)	Radiant (F)	Radiant (F)
5	Verimark (D) 10.3 oz	Verimark (D) 10.3 oz	Vydate(D)	Vydate (D)	Radiant (F)	Radiant (F)
6	Exirel (F)	Exirel (F)	Lannate (F)	Lannate (F)	Radiant (F)	Radiant (F)
7	Movento (F)	Movento (F)	Lannate (F)	Lannate (F)	Radiant (F)	Radiant (F)
8	Verimark (D) 10.3 oz	Lannate (F)	Lannate (F)	Lannate (F)	Radiant (F)	Radiant (F)

Table 9. Characteristics of insecticides tested in 8 treatment programs for efficacy against onion thrips. Treatments were applied by drip or foliar applications (see Table 8). Malheur Experiment Station, Oregon State University, Ontario, OR, 2014.

NOT ALL INSECTICIDES USED IN THESE TRIALS ARE CURRENTLY REGISTERED FOR USE ON ONIONS. PLEASE CONSULT THE LABEL TO DETERMINE APPROPRIATE USES.

Product	Company	Rate (product/acre)	Adjuvant	Active ingredient	Mode of action group
Exirel (10% SE)	DuPont	13.5 fl oz	MSO 0.5% v:v	Cyazypyr	28
Lannate LV	DuPont	3 pt	Preference 0.25% v/v	Methomyl	1A
Movento	Bayer	5 fl oz	MSO 0.5% v/v	Spirotetramat	23
Radiant	Dow	8 fl oz	Dyne-Amic 3.75% v/v	Spinetoram	5
Verimark	DuPont	6.75 oz (trt 3) 10.3 oz (trt 4,5,8)		Cyazypyr	28
Vydate	DuPont	2 qt / ac		Oxamyl	1A

Table 10. Mean total numbers of thrips per onion plant by sampling date in response to 8 drip or foliar insecticide treatments. Insecticide applications were made weekly, beginning on May 27 and concluding on July 17. Means on each sample date marked with the same letter are not significantly different. Malheur Experiment Station, Oregon State University, Ontario, OR, 2014.

	Rating date											
Treatment	6/2		6/10		6/20		6/30		7/10		7/21	
number	mean total thrips/plant											
1	4.5	a	40.6	ab	50.4	ab	167.7	a	94.8	ab	30.9	a
2	4.8	a	50.9	a	50.3	ab	144.9	ab	80.9	b	18.7	a
3	6.5	a	52.7	a	26.7	bc	86.1	bc	141.3	ab	18.2	a
4	5.9	a	39.2	ab	23.8	bc	88.2	bc	140.0	ab	19.2	a
5	5.4	a	46.3	a	50.0	ab	142.5	ab	78.2	b	14.9	a
6	4.2	a	48.0	a	41.8	ab	84.6	bc	137.6	ab	14.0	a
7	4.8	a	22.6	b	14.7	c	45.0	c	152.6	a	18.3	a
8	5.6	a	18.6	b	13.6	c	73.5	bc	138.1	ab	17.6	a

Table 11. Mean number of adult thrips per onion plant listed by sampling date in response to 8 drip or foliar insecticide treatments. Insecticide applications were made weekly, beginning on May 27 and concluding on July 17. Means on each sample date marked with the same letter are not significantly different. Malheur Experiment Station, Oregon State University, Ontario, OR, 2014.

	Rating date											
Treatment	6/2		6/10		6/20		6/30		7/10		7/21	
number	mean adult thrips/plant											
1	1.5	a	9.2	a	10.2	a	18.1	ab	10.8	A	1.1	a
2	2.7	a	10.3	a	14.4	a	15.0	b	10.3	A	1.4	a
3	1.9	a	7.5	a	5.0	b	21.2	ab	15.6	A	1.6	a
4	1.9	a	7.4	a	3.9	b	24.3	a	12.0	A	1.4	a
5	2.0	a	10.0	a	12.2	a	14.0	b	11.5	a	1.2	a
6	2.4	a	10.3	a	4.1	b	21.4	ab	9.0	a	1.8	a
7	1.3	a	7.9	a	4.4	b	21.3	ab	10.3	a	2.6	a
8	2.0	a	7.8	a	5.1	b	21.3	ab	7.7	a	1.8	a

Table 12. Mean numbers of larval thrips per onion plant listed by sampling date in response to 8 drip or foliar insecticide treatments. Insecticide applications were made weekly, beginning on May 27 and concluding on July 17. Means on each sample date marked with the same letter are not significantly different. Malheur Experiment Station, Oregon, State University, Ontario, OR, 2014.

	Rating date											
Treatment	6/2		6/10		6/20		6/30		7/10		7/21	
number	---------- mean larval thrips/plant ----------											
1	3.3	a	29.4	abc	37.4	ab	149.6	a	81.0	abc	28.8	a
2	1.8	a	38.3	ab	35.5	ab	130.0	ab	67.5	bc	16.9	a
3	4.6	a	43.5	a	19.8	b	64.9	bc	121.1	ab	15.7	a
4	4.2	a	30.6	abc	19.6	b	63.8	bc	125.1	ab	16.8	a
5	3.4	a	35.4	abc	35.7	ab	128.5	ab	63.9	c	12.6	a
6	2.1	a	35.2	abc	35.1	ab	63.1	bc	125.9	ab	10.8	a
7	3.7	a	13.5	bc	9.1	c	23.7	c	140.2	a	13.8	a
8	3.6	a	9.7	c	7.8	c	52.2	c	127.6	ab	13.6	a

Table 13. Visual damage ratings for thrips feeding damage and iris yellow spot virus (IYSV) severity in response to 18 drip or foliar insecticide treatments. Data are the mean damage ratings (0-4 scale) of 10 plants per plot. Separate ratings were made on the outer, middle, and inner leaves of the same plants per plot. Ratings were done on 8 August. Means marked with the same letter are not significantly different. Malheur Experiment Station, Oregon State University, Ontario, OR, 2014.

Rating Date	IYSV - inner		IYSV - middle		IYSV - outer		Thrips - inner		Thrips - middle		Thrips - outer	
1	1.3	a	2.0	a	1.5	a	2.3	a	3.0	a	3.0	a
2	1.2	a	2.0	a	1.5	a	1.6	a	2.5	a	2.7	a
3	1.4	a	2.2	a	1.9	a	2.3	a	3.0	a	3.3	a
4	1.5	a	2.0	a	1.8	a	2.2	a	2.7	a	2.9	a
5	1.3	a	2.1	a	1.7	a	2.0	a	2.9	a	3.0	a
6	1.1	a	2.2	a	2.0	a	1.9	a	2.8	a	3.0	a
7	1.3	a	1.9	a	1.7	a	2.1	a	2.9	a	3.2	a
8	1.4	a	1.7	a	1.6	a	2.0	a	2.7	a	2.8	a

Table 14. Onion yield in response to eight drip- or foliar-applied insecticide treatment regimes. Data are the mean number of hundredweight per acre (cwt/acre) for the different yield categories. Means marked with the same letter are not significantly different. Malheur Experiment Station, Oregon State University, Ontario, OR, 2014.

Treatment number	Small		Medium		Jumbo		Colossal		Supercolossal		Marketable		Total	
	cwt/acre													
1	2.9	a	37.6	a	614.7	a	109.8	a	1.9	a	771.1	a	774.8	a
2	8.0	a	20.8	a	651.8	a	145.6	a	6.5	a	826.5	a	835.3	a
3	4.1	a	39.4	a	653.5	a	104.5	a	4.5	a	806.7	a	811.0	a
4	5.6	a	27.8	a	585.3	a	110.5	a	5.8	a	741.0	a	746.8	a
5	4.5	a	35.9	a	677.3	a	96.7	a	6.2	a	819.3	a	824.2	a
6	3.0	a	32.9	a	633.2	a	121.3	a	7.7	a	811.4	a	814.5	a
7	4.9	a	28.2	a	638.0	a	202.0	a	4.4	a	876.1	a	881.3	a
8	5.8	a	31.3	a	559.7	a	98.6	a	5.4	a	715.6	a	721.6	a