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

Stuart Reitz, Malheur County Extension, Ontario, OR, 2015

Clint Shock, Erik Feibert, Alicia Rivera, Lamont Saunders, Malheur Experiment Station, Ontario, OR

Eric Jemmett, Jemmett Research Farms, Parma, ID

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 makes for unique production challenges, especially for onion thrips and iris yellow spot virus management. Thrips are able to 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 regimes in which products were applied by drip application or by foliar application.

Trial 1: Foliar Insecticide Trial Materials and Methods

Cultural practices

Onion seed of variety 'Vaquero' was planted at 150,000 seeds/acre on March 10, 2015. Emergence started on March 30.

The field had drip tape laid at 4-inch depth between 2 onion beds during planting. The drip tape had emitters spaced 12 inches apart and an emitter flow rate of 0.22 gal/min/100 ft (T-Tape, Rivulis USA, San Diego, CA). The distance between the tape and the center of each double row of onions was 11 inches.

Onions were irrigated automatically to maintain the soil water tension (SWT) in the onion root zone below 20 cb. Soil water tension was measured with six granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Riverside, CA) installed at 8-inch depth in the center of the double row. Sensors had been calibrated to SWT. Irrigations were run by a controller programmed to irrigate twice a day applying 0.48 inch of water per irrigation. A Watermark Electronic Module (WEM, Irrometer Co.) was adjusted to override controller irrigations if the SWT was below 20 cb. Four Watermark sensors were connected to the WEM. The last irrigation was on August 24.

For weed control, the following herbicides were applied: on March 30, Roundup PowerMax® at 24 oz/acre was broadcast; on May 1, GoalTender® at 0.09 lb ai/acre (4 oz/acre), Buctril® at 0.25 lb ai/acre (16 oz/acre), and Poast® at 0.25 lb ai/acre (16 oz/acre) were broadcast; on May 4, Prowl® H_2O at 0.83 lb ai/acre (2 pt/acre) was broadcast.

For disease control, Badge® fungicide at 0.28 lb ai/acre (1 pt/acre) was broadcast aerially on June 4.

URAN at 20 lb nitrogen (N)/acre was applied through the drip tape weekly starting May 28 and ending June 24, totaling 100 lb N/acre.

Foliar insecticide applications

Insecticides were applied weekly beginning May 26, 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 4 (before applications began). Thrips counts were made by counting the number of thrips on 10 consecutive plants in one of the middle two 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 two 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

Onions were lifted on August 31 and were topped and bagged on September 7. Onions from the middle two double rows in each plot were topped by hand and bagged on September 16 and placed in storage. The onions from each plot were graded on October 12 and 13. 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 2015 than the 30-year historical averages (Fig. 1). The warm early spring temperatures likely contributed to an early buildup of thrips populations.

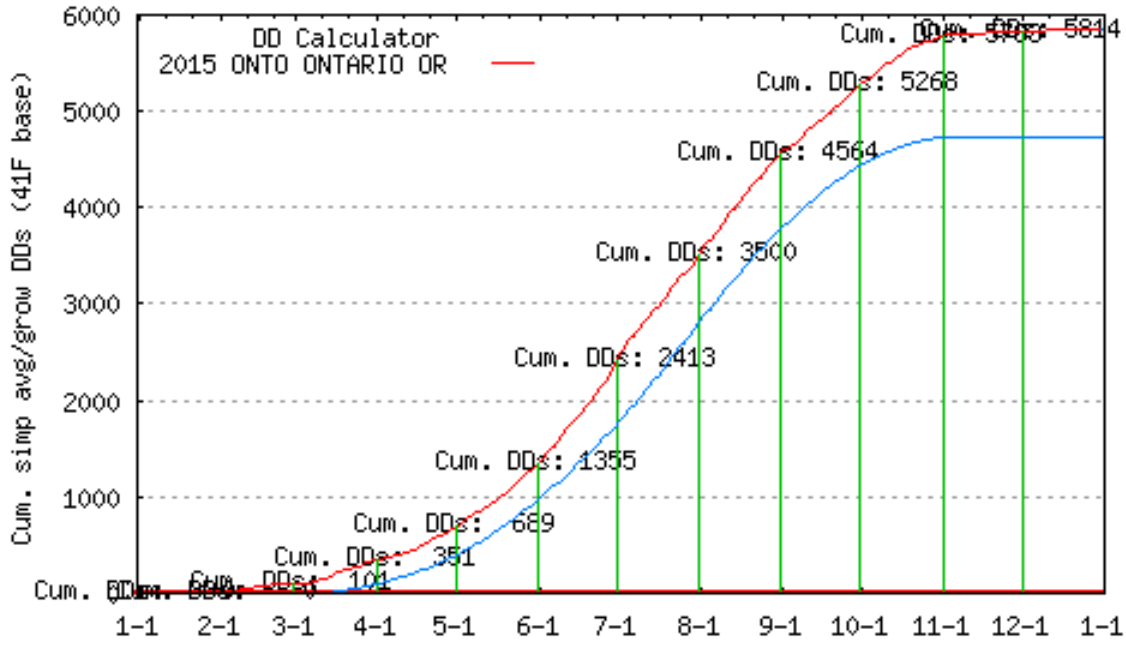

Figure 1. Comparison of the accumulated degree-days for 2015 versus the 30-year average, as recorded at Ontario, OR. The upper line represents the 2015 degree days (base 50°F), and the lower line represents the historical averages.

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

Season-long control of adult thrips was best in programs that used early season applications of Movento®. The program with tank-mixing of Requiem® was effective, but control was no better than corresponding programs without Requiem.

Programs that started with Aza-Direct® showed a lack of control but applications of Movento that followed improved control. This delayed use of Movento may make better use of Movento's residual control of immatures when thrips populations are peaking in late June and early July. Delayed use of Movento may require combination with an effective adulticide to prevent populations from building too rapidly.

Early season applications of Radiant® kept larval thrips numbers low; however, control in this program (no. 10) was reduced as the residual effect of Radiant dissipated and Movento had not built to effective levels. The second application of Movento improved control.

Table 1. Insecticide sequences treatments tested for efficacy against onion thrips and iris yellow spot virus. Malheur Experiment Station, Oregon State University, Ontario, OR, 2015. Sequences with unregistered products are not listed.

Application date	May 26	Jun 2	Jun 9	Jun 16	Jun 23	Jun 30	Jul 6	Jul 13
				Application number				
Treatment	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**
1	Control	-	-	-	-	-	-	-
2	Movento	Movento	Agri-Mek	Agri-Mek	Radiant	Radiant	Lannate	Lannate
3	M-Pede + Aza-Direct	Aza-Direct + Movento	Movento	Captiva 11 oz	Lannate + Captiva 7 oz	Lannate + Captiva 7 oz	Radiant	Radiant
4	M-Pede + Azadirect	Azadirect + Movento	Movento	Captiva 11 oz	Agri-Mek + Capitva 7 oz	Agri-Mek + Capitva 7 oz	Radiant	Radiant
5	M-Pede + Aza-Direct	Movento + Aza-Direct	Movento	Lannate		Radiant + M-Pede		Radiant + M-Pede
6	Movento + PureSpray Green 0.25 gal	Movento + PureSpray Green 0.25 gal	Agri-Mek + PureSpray Green 0.25 gal	Agri-Mek + PureSpray Green 0.25 gal	Radiant + PureSpray Green 0.25 gal	Radiant + PureSpray Green 0.25 gal	Lannate + PureSpray Green 0.25 gal	Lannate + PureSpray Green 0.25 gal
7	PureSpray Green 1 gal	PureSpray Green 1 gal	Movento + PureSpray Green 0.5 gal	Movento + PureSpray Green 0.5 gal	Agri-Mek + PureSpray Green 0.5 gal	Agri-Mek + PureSpray Green 0.5 gal	Radiant + PureSpray Green 0.5 gal	Radiant + PureSpray Green 0.5 gal
8	PureSpray Green 2 gal	PureSpray Green 2 gal	Movento + PureSpray Green 0.5 gal	Movento + PureSpray Green 0.5 gal	Agri-Mek + PureSpray Green 0.5 gal	Agri-Mek + PureSpray Green 0.5 gal	Radiant + PureSpray Green 0.5 gal	Radiant + PureSpray Green 0.5 gal

Application date	May 26	Jun 2	Jun 9	Jun 16	Jun 23	Jun 30	Jul 6	Jul 13
9	PureSpray Green 1 gal	PureSpray Green 1 gal	Movento + PureSpray Green 0.5 gal	Movento + PureSpray Green 0.5 gal	Agri-Mek + PureSpray Green 0.5 gal	Agri-Mek + PureSpray Green 0.5 gal	PureSpray Green 1 gal	PureSpray Green 1 gal
10	Radiant	Radiant	Movento	Movento	Lannate	Lannate	Agri-Mek	Agri-Mek
11	Movento	Movento	Radiant	Radiant	Lannate	Lannate	Agri-Mek	Agri-Mek
12	Agri-Mek	Agri-Mek	Movento	Movento	Radiant	Radiant	Lannate	Lannate
16	Movento + Lannate	Movento	Agri-Mek	Agri-Mek	Radiant	Radiant	Lannate	Lannate
17	Movento (Admire soil drench 4/23)	Movento	Agri-Mek	Agri-Mek	Radiant	Radiant	Lannate	Lannate
18	Movento + Requiem 2 qt (Admire soil drench 4/23)	Movento + Requiem 2 qt	Agri-Mek + Requiem 2 qt	Agri-Mek + Requiem 2 qt	Radiant	Radiant	Lannate	Lannate
19	Movento + Requiem Prime 2 qt (Admire soil drench 4/23)	Movento + Requiem Prime 2 qt	Agri-Mek + Requiem Prime 2 qt	Agri-Mek + Requiem Prime 2 qt	Radiant	Radiant	Lannate	Lannate

Application date	May 26	Jun 2	Jun 9	Jun 16	Jun 23	Jun 30	Jul 6	Jul 13
20	Movento + Requiem Prime 1 qt (Admire soil drench 4/23)	Movento + Requiem Prime 1 qt	Agri-Mek + Requiem Prime 1 qt	Agri-Mek + Requiem Prime 1 qt	Radiant	Radiant	Lannate	Lannate
21	Movento (Sivanto soil drench 4/23)	Movento	Agri-Mek	Agri-Mek	Radiant	Radiant	Lannate	Lannate

Table 2. Characteristics of insecticides tested in 21 foliar treatments for efficacy against onion thrips. Sequences with unregistered products are not listed. **Please consult the label to determine appropriate uses**. Malheur Experiment Station, Oregon State University, Ontario, OR, 2015.

Product	Company	Rate (product per acre)	Adjuvant	Active ingredient	pH	Mode of action group
Admire Pro	Bayer	14 fl oz		imidacloprid	6.5	4A
Agri-Mek SC	Syngenta	3.5 fl oz	MSO 0.5% v/v	abamectin	7.0	6
Aza-Direct	Gowan	12 fl oz	-	azadirachtin		unknown
Captiva	Gowan	7/11 fl oz		capsacin oleoresin, garlic oil, soybean oil	7.0	unknown
Lannate LV	DuPont	3 pt	Preference 0.25% v/v	methomyl	5.0	1A
M-Pede	Gowan	5.6 pt	-	potassium salts of fatty acids		unknown
Movento	Bayer	5 fl oz	MSO 0.5% v/v	spirotretramat	6.5	23
PureSpray Green	PetroCanada	0.25–2.0 gal	None	refined oil		unknown
Radiant	Dow	8 fl oz	Dyne-Amic 3.75% v/v	spinetoram	7.0	5
Requiem EC	Bayer	2 qt		synthetic terpenes derived from *Chenopodium ambrosioides*		unknown
Requiem Prime	Bayer	1–2 qt		synthetic terpenes derived from *Chenopodium ambrosioides*		unknown
Sivanto	Bayer	21 fl oz		flupyradifurone	6.5	4D

Table 3. Mean numbers of thrips (total) per onion plant listed by sampling date in response to 21 foliar insecticide programs. Insecticide applications were made weekly, beginning on May 28 and concluding on July 17. Malheur Experiment Station, Ontario, Oregon, 2015.

Treatment number	Mean total thrips/plant							
	Sampling date							
	May 29	Jun 4	Jun 11	Jun 18	Jun 25	Jul 2	Jul 10	Jul 17
1	31.4	28.4	41.9	98.4	73.3	81.3	37.1	17.8
2	27.2	26.6	16.6	16.7	15.8	6.7	2.5	5.4
3	28.8	33.8	23.0	21.9	9.8	8.0	2.5	6.0
4	28.3	24.5	20.3	24.7	15.3	6.0	1.6	3.9
5	32.8	32.7	25.5	12.2	26.0	18.1	21.5	7.3
6	26.2	26.9	26.2	40.5	33.2	13.6	8.0	5.6
7	29.8	31.7	43.0	71.1	32.7	30.8	2.7	6.7
8	27.1	30.0	40.5	100.5	39.0	9.6	2.9	2.1
9	30.6	32.3	41.4	73.5	34.7	12.6	6.9	9.0
10	16.1	26.8	34.9	27.6	12.9	8.8	4.3	11.4
11	24.6	27.1	11.3	17.4	15.4	18.2	8.9	18.6
12	30.6	21.2	26.5	54.4	16.6	4.6	1.8	6.6
16	16.3	36.3	13.6	14.4	11.4	7.5	7.5	6.0
17	20.5	27.4	13.3	17.1	12.5	12.7	3.2	4.6
18	29.8	23.3	10.6	11.2	9.3	3.4	2.0	5.2
19	21.8	26.1	19.9	13.6	9.3	1.8	1.9	1.8
20	26.7	29.1	20.1	21.7	22.0	3.9	2.5	3.9
21	26.7	23.5	23.7	46.1	34.9	6.2	2.8	2.0

Table 4. Mean numbers of adult thrips per onion plant listed by sampling date in response to 21 foliar insecticide programs. Insecticide applications were made weekly, beginning on May 28 and concluding on July 17. Malheur Experiment Station, Ontario, Oregon, 2015.

Treatment number	Mean adult thrips/plant							
	Sampling date							
	May 29	Jun 4	Jun 11	Jun 18	Jun 25	Jul 2	Jul 10	Jul 17
1	4.1	4.8	15.3	12.6	22.3	11.4	1.6	1.4
2	4.0	5.4	8.2	10.7	4.2	2.3	1.4	0.7
3	3.6	6.2	8.4	17.2	7.7	7.6	0.6	0.5
4	4.3	5.6	7.6	18.0	11.3	5.1	0.8	1.2
5	3.2	5.2	10.7	9.2	20.4	13.1	4.1	0.7
6	3.1	5.4	10.2	11.0	3.5	6.0	1.2	0.4
7	3.6	5.7	11.2	12.2	18.4	13.0	0.8	1.7
8	3.5	5.1	10.0	13.8	17.2	7.5	0.9	1.0
9	4.4	4.8	9.4	12.1	15.3	10.2	4.4	1.6
10	2.2	2.7	15.6	20.8	9.3	7.7	2.7	1.1
11	3.3	4.5	5.2	3.7	8.1	5.6	2.1	1.9
12	2.8	3.8	9.1	9.1	13.3	4.0	0.9	3.2
16	2.2	5.5	9.0	9.8	5.7	3.3	2.3	0.6
17	3.9	3.8	8.0	7.5	4.5	2.7	1.7	0.4
18	3.8	4.8	8.0	6.6	4.7	1.5	1.2	1.2
19	2.9	5.1	9.0	9.8	6.0	1.3	0.9	1.0
20	3.9	8.1	8.4	11.4	6.4	2.4	1.4	0.7
21	2.5	4.9	12.0	11.5	3.1	3.3	1.6	0.3

Table 5. Mean numbers of larval thrips per onion plant listed by sampling date in response to 21 foliar insecticide programs. Insecticide applications were made weekly, beginning on May 28 and concluding on July 17. Malheur Experiment Station, Oregon, 2015.

Treatment number	Mean larval thrips/plant							
	Sampling date							
	May 29	Jun 4	Jun 11	Jun 18	Jun 25	Jul 2	Jul 10	Jul 17
1	27.3	23.6	26.5	85.9	51.0	69.9	35.5	16.4
2	23.2	21.3	8.4	6.0	11.6	4.4	1.1	4.7
3	25.0	27.6	14.6	4.7	2.1	0.5	1.9	5.5
4	24.0	18.9	12.8	6.7	3.9	0.9	0.8	2.7
5	29.5	27.5	14.8	3.1	5.6	5.0	17.5	6.6
6	23.1	21.5	16.0	29.5	29.7	7.6	6.8	5.1
7	26.2	26.0	31.8	58.9	14.3	17.8	1.9	5.1
8	23.6	25.0	30.5	86.7	21.8	2.1	2.0	1.1
9	26.3	27.5	32.0	61.4	19.4	2.4	2.6	7.4
10	13.9	24.1	19.3	6.8	3.6	1.1	1.6	10.3
11	21.3	22.6	6.2	13.7	7.3	12.7	6.8	16.7
12	27.8	17.4	17.4	45.3	3.3	0.6	0.9	3.4
16	14.1	30.8	4.7	4.6	5.7	4.2	5.2	5.4
17	16.6	23.6	5.3	9.6	8.0	10.1	1.5	4.2
18	26.0	18.5	2.6	4.6	4.6	1.9	0.8	4.0
19	18.9	21.0	10.9	3.8	3.3	0.5	1.0	0.8
20	22.8	21.0	11.7	10.3	15.5	1.5	1.1	3.2
21	24.2	18.6	11.8	34.6	31.8	2.9	1.2	1.7

Table 6. Onion yield in response to 21 foliar-applied insecticide treatment programs. 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. The only statistical differences were seen in the colossal size. Malheur Experiment Station, Oregon State University, Ontario, OR, 2015.

Treatment number	Small		Medium		Jumbo		Colossal		Supercolossal		Marketable yield		Total yield	
	cwt/acre													
1	7.72	a	45.35	a	668.15	a	40.86	d	3.25	a	757.61	a	774.66	a
2	2.20	a	29.31	a	661.00	a	284.40	ab	16.97	a	991.67	a	1005.67	a
3	3.05	a	14.51	a	681.32	a	309.09	a	12.71	a	1017.63	a	1058.06	a
4	6.25	a	42.66	a	767.88	a	288.97	abc	7.18	a	1106.69	a	1122.68	a
5	2.56	a	23.27	a	596.46	a	76.99	cd	0.00	a	696.71	a	711.59	a
6	2.61	a	15.75	a	553.48	a	206.51	ab	10.56	a	786.30	a	802.27	a
7	3.51	a	23.50	a	605.24	a	223.71	ab	13.17	a	865.62	a	878.63	a
8	7.02	a	23.27	a	715.93	a	147.08	bc	2.17	a	888.45	a	903.22	a
9	4.26	a	24.20	a	645.81	a	235.10	ab	7.05	a	912.16	a	947.00	a
10	8.29	a	30.63	a	684.24	a	273.06	ab	16.22	a	1004.15	a	1058.77	a
11	6.92	a	23.48	a	637.16	a	180.50	abc	11.80	a	852.94	a	866.68	a
12	6.22	a	22.55	a	563.66	a	152.25	abc	5.63	a	744.08	a	762.11	a
16	3.31	a	12.47	a	523.73	a	270.12	a	21.77	a	828.09	a	850.48	a
17	9.07	a	30.37	a	596.38	a	225.80	ab	12.16	a	864.71	a	884.78	a
18	4.52	a	35.49	a	644.24	a	278.95	ab	9.50	a	968.17	a	982.56	a
19	4.86	a	26.58	a	612.57	a	170.89	abc	12.32	a	822.36	a	837.36	a
20	4.73	a	25.00	a	626.83	a	162.86	abc	15.11	a	829.80	a	849.32	a
21	6.97	a	22.16	a	632.12	a	153.98	abc	9.61	a	817.86	a	839.97	a

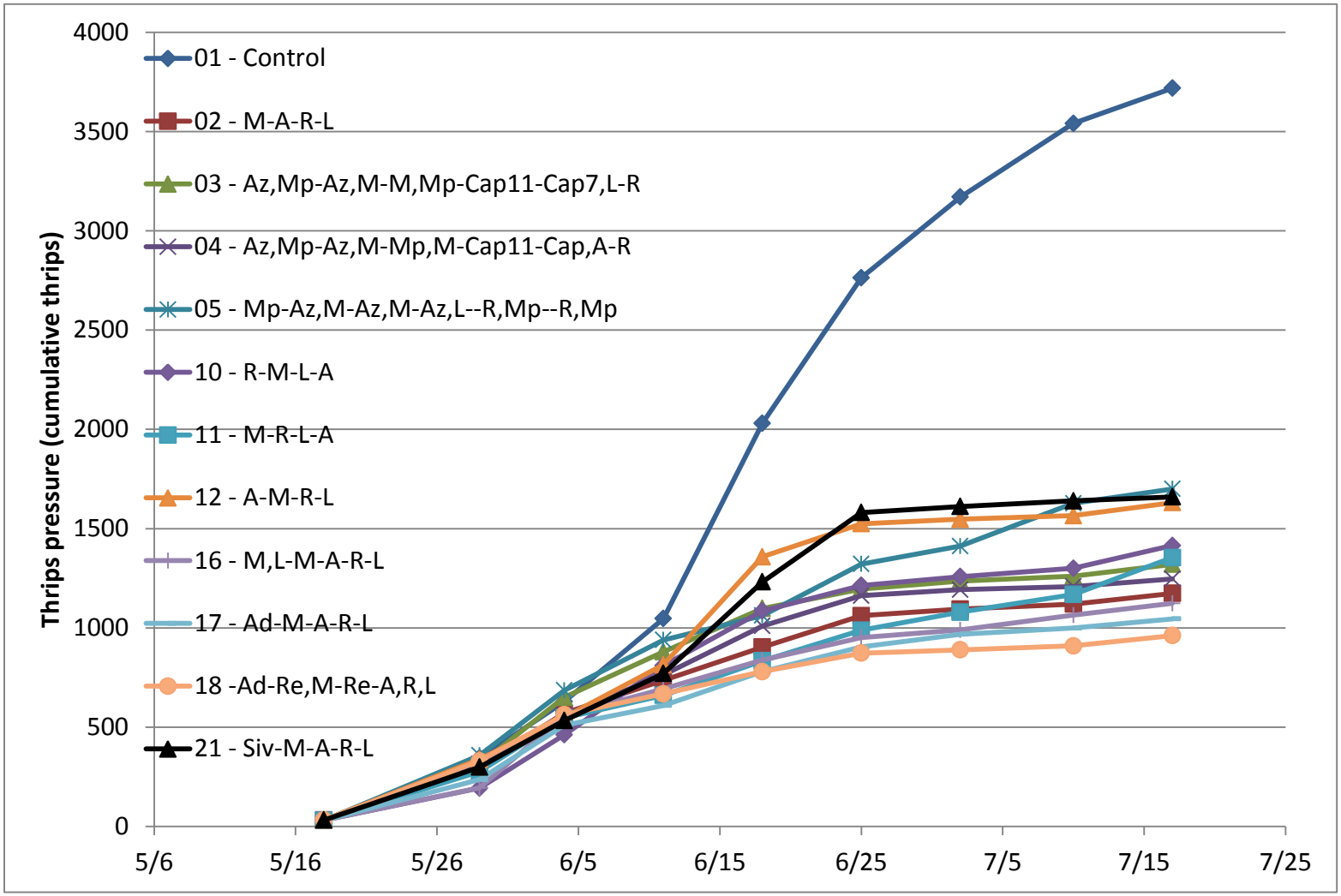

Figure 2. Cumulative thrips pressure in foliar application trial over the 2015 growing season, Malheur Experiment Station, Ontario, OR. Data are mean cumulative thrips per plot (10 plants). See Table 1 for treatment descriptions. Smaller increases from sample date to sample date indicate better thrips control.

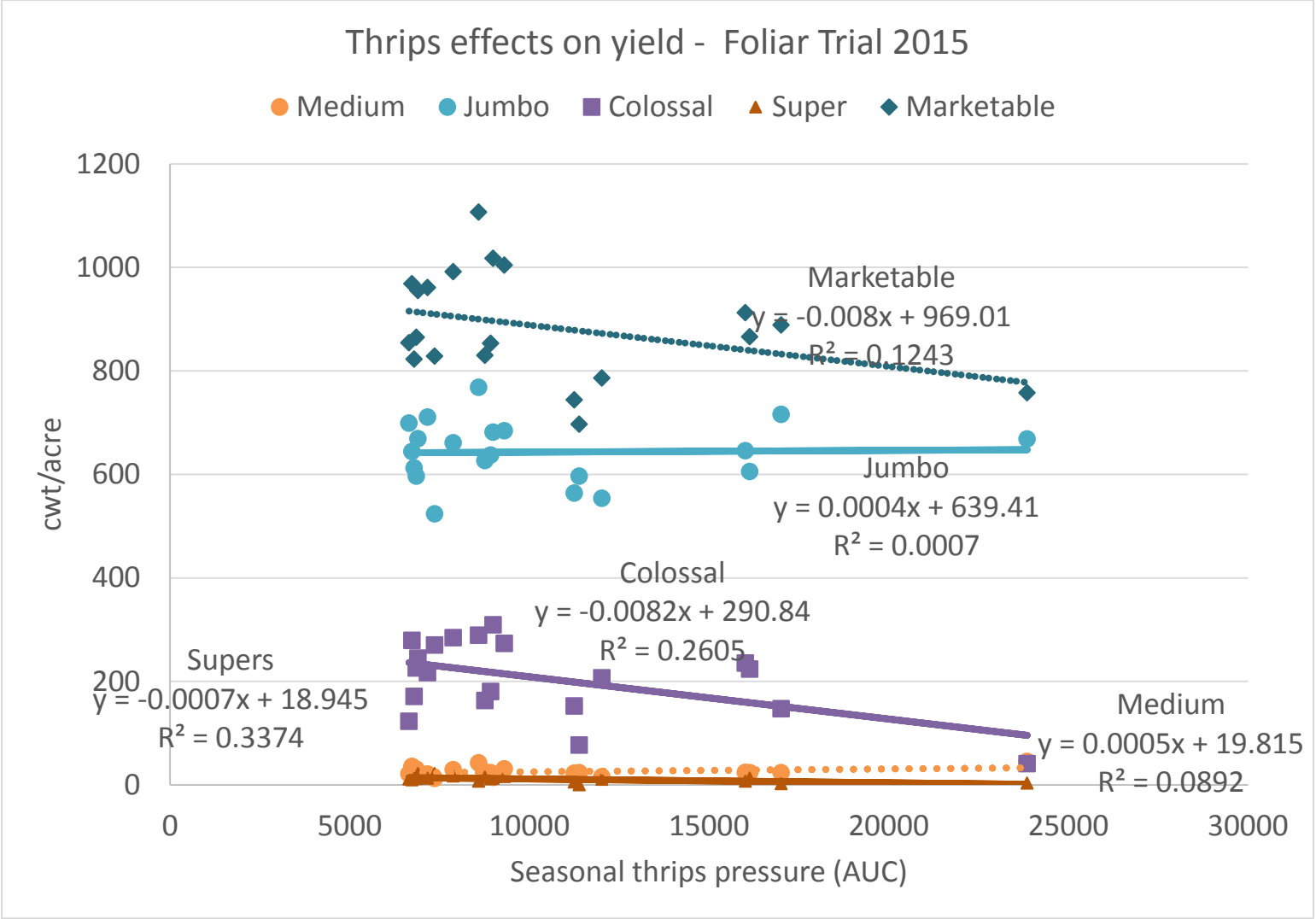

Figure 3. Effect of cumulative numbers of thrips over the growing season on onion yield. Malheur Experiment Station, Ontario, OR, 2015. As thrips pressure increases over the season, marketable yield goes down. There are also significant declines in the larger (colossal, supercolossal) size classes.

Trial 2: Drip Insecticide Applications
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 26, according to the schedule and rates listed in Tables 7 and 8. Drip applications were made by injecting appropriate amounts of the product over a 4-hour period. Injections began about 30 min after irrigation started. Irrigation continued for 4 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 8 total applications were made in this trial.

Data collection

Thrips counts were made starting on May 4 (before applications began). After applications began, counts were made 3-4 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 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 growing season.

Onions were lifted on August 31 and were topped and bagged on September 7. Onions from the middle two double rows in each plot were topped by hand and bagged on September 16 and placed in storage. The onions from each plot were graded on October 12 and 13. 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

The early season drip applications of Verimark® were as effective as the foliar standard of starting with two applications of Movento. Vydate® applied as a drip treatment with foliar-applied Movento did not improve control compared with Movento applied by itself.

Exirel® and Verimark contain the same active ingredient, cyazypyr. However, foliar applied Exirel was not as effective as drip-applied Verimark, in terms of total numbers of thrips (adults and immatures combined).

Over the entire season, treatment programs that started either with Movento (foliar) or Verimark (drip) were the most effective. Programs with foliar or drip applications of Aza-Direct resulted in intermediate thrips control.

No individual insecticides or season-long treatment programs were effective in reducing the numbers of adult thrips. This lack of effectiveness is probably due in part to adult thrips continuing to disperse into our small research plots. Greater effects are likely to be seen in large commercial fields. However, thrips dispersal into commercial fields may mean that populations at the edges of fields will be different from populations in the center of fields. These differences should be considered in scouting programs.

Foliar applications of Movento and the program with two drip applications of Verimark provided the best control of immature thrips, which comprise the majority of thrips populations. These applications seemed to provide good residual control as populations remained low for up to 2 sampling periods (~3 weeks) after the second application. The program with a single application of Verimark by drip followed by three foliar applications of Lannate® had noticeably less control than programs with two applications of Verimark or Movento.

Radiant provided effective mid- to late-season control of immature thrips.

In terms of season-long control of immatures, the programs that started with two applications of Movento or Verimark were the most successful. The good early season control and residual effects helped to keep populations from building during the typical peak in late June and early July. Although Aza-Direct was not highly effective in early season applications, its use at the beginning of the spray program allowed Movento to be used later in the season. This later use of Movento made use of its residual control when thrips populations were at their peak.

There were no significant differences in yields among the ten different treatment programs (Table 14). Although not statistically different, treatment program 7, which represented a “foliar standard” had approximately 40-108% more colossal bulbs compared to the other treatment programs.

Although the drip applications did not improve thrips management, 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 7. Insecticide sequence treatments tested for efficacy against onion thrips and iris yellow spot virus. Malheur Experiment Station, Oregon State University, Ontario, OR, 2015. Applications were made by drip (D) or foliar (F) application. Sequences with unregistered products are not listed.

Application date	May 26	Jun 6	Jun 16	Jun 25	Jul 7	Jul 17	Jul 27	Aug 6
			Application number					
Treatment	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**
1	Control	-	-	-	-	-		
2	Verimark (D)	Verimark (D)	Lannate (F)	Lannate (F)	Radiant (F)	Radiant (F)	Lannate (F)	Lannate (F)
3	Verimark (D)	Lannate (F)	Lannate (F)	Lannate (F)	Radiant (F)	Radiant (F)		
4	Exirel (F) + Vydate (D) + Fontelis (D) for pink root	Exirel (F)	Lannate (F)	Lannate (F) + Fontelis (D) for pink root	Radiant (F)	Radiant (F)	Lannate (F)	Lannate (F)
5	Verimark (D) 10.3 oz	Verimark (D) 10.3 oz	Vydate(D)	Vydate (D)	Radiant (F)	Radiant (F)	-	-
6	Movento (F)	Movento (F)	Lannate (F)	Lannate (F)	Radiant (F)	Radiant (F)	Lannate (F)	Lannate (F)
7	Movento (F) Vydate (D) + Fontelis (D) for pink root	Movento (F)	Lannate (F)	Lannate (F) + Fontelis (D) for pink root	Radiant (F)	Radiant (F)	Lannate (F)	Lannate (F)
8	Aza-Direct 32 fl oz (D)	Aza-Direct 32 fl oz (D)	Movento (F)	Movento (F)	Radiant (F)	Radiant (F)	Agri-Mek (F)	Agri-Mek (F)

Application date	May 26	Jun 6	Jun 16	Jun 25	Jul 7	Jul 17	Jul 27	Aug 6
9	Aza-Direct 12 fl oz (F) + M-Pede (F)	Aza-Direct 12 fl oz (F) + M-Pede (F)	Movento (F)	Movento (F)	Radiant (F)	Radiant (F)	Agri-Mek (F)	Agri-Mek (F)
10	Movento (F)	Movento (F)	Agri-Mek (F)	Agri-Mek (F)	Radiant (F)	Radiant (F)	Lannate (F)	Lannate (F)

Table 8. Characteristics of insecticides tested in 10 treatment programs for efficacy against onion thrips. Treatments were applied by drip or foliar applications (see Table 7). Sequences with unregistered products are not listed. **Please consult the label to determine appropriate uses.** Malheur Experiment Station, Oregon State University, Ontario, OR, 2015.

Product	Company	Rate (product per acre)	Adjuvant	Active ingredient	pH	Mode of action group
Agri-Mek SC	Syngenta	3.5 fl oz	MSO 0.5% v/v	abamectin	7.0	6
Aza-Direct	Gowan	12 – 32 fl oz	-	azadirachtin	6.0	unknown
Exirel 10% SE	DuPont	13.5 fl oz	MSO 0.5% v:v	cyazypyr	5.0	28
Lannate LV	DuPont	3 pt	Preference 0.25% v/v	methomyl	5.0	1A
M-Pede	Gowan	5.6 pt	-	potassium salts of fatty acids		unknown
Movento	Bayer	5 fl oz	MSO 0.5% v/v	spirotretramat	6.5	23
Radiant	Dow	8 fl oz	Dyne-Amic 3.75% v/v	spinetoram	7.0	5
Verimark	DuPont	10.3 oz	-	cyazypyr	5.0	28
Vydate	DuPont	2 qt / ac	-	oxamyl	5.0	1A

Table 9. Mean numbers of thrips (total) per onion plant listed by sampling date in response to 10 drip or foliar insecticide programs. Insecticide applications were made every 10 days, beginning on May 26 and concluding on August 6. Malheur Experiment Station, Ontario, OR, 2015.

Treatment number	Mean total thrips/plant							
	Sampling date							
	May 29	Jun 9	Jun 19	Jun 29	Jul 10	Jul 20	Jul 30	Aug 10
1	28.4	49.4	75.5	75.6	69.8	12.5	3.3	0.7
2	22.5	30.2	18.0	52.2	25.0	1.1	0.8	0.2
3	28.2	30.8	54.3	68.5	18.0	1.4	0.6	1.1
4	26.9	42.4	60.9	66.8	29.6	2.1	1.4	0.2
5	16.8	44.4	44.6	81.1	26.0	3.4	1.2	0.3
6	24.1	20.9	10.9	27.3	47.9	6.0	1.3	0.4
7	23.3	27.1	11.5	20.4	29.0	2.7	0.8	0.4
8	24.5	38.5	75.2	20.2	2.3	0.9	1.3	0.4
9	25.6	40.0	64.4	19.0	3.6	2.0	1.4	0.2
10	21.4	23.0	25.0	30.5	28.4	1.1	1.3	0.1

Table 10. Mean numbers of adult thrips per onion plant listed by sampling date in response to drip or foliar insecticide programs. Insecticide applications were made every 10 days, beginning on May 26 and concluding on August 6. Malheur Experiment Station, Ontario, OR, 2015.

Treatment number	Mean adult thrips/plant							
	Sampling date							
	May 29	Jun 9	Jun 19	Jun 29	Jul 10	Jul 20	Jul 30	Aug 10
1	3.7	10.3	13.1	14.5	2.1	1.1	0.5	0.3
2	3.9	7.3	7.2	12.3	1.1	0.5	0.1	0.1
3	3.8	11.6	6.2	14.4	0.5	0.1	0.1	0.2
4	3.3	13.7	5.5	11.9	1.8	0.3	0.2	0.1
5	3.1	15.8	5.8	15.2	0.8	0.1	0.2	0.1
6	3.2	7.6	5.8	11.1	0.8	0.5	0.2	0.1
7	3.3	12.2	8.3	10.8	0.7	0.3	0.1	0.1
8	4.5	9.1	12.5	14.5	1.7	0.6	0.3	0.1
9	3.3	9.6	9.9	13.9	1.1	0.5	0.5	0.1
10	2.3	8.9	13.7	8.8	0.7	0.2	0.5	0.1

Table 11. Mean numbers of immature thrips per onion plant listed by sampling date in response to 10 drip or foliar insecticide programs. Insecticide applications were made every 10 days, beginning on May 26 and concluding on August 6. Malheur Experiment Station, Ontario, OR, 2015.

Treatment number	Mean immature thrips/plant							
	Sampling date							
	May 29	Jun 9	Jun 19	Jun 29	Jul 10	Jul 20	Jul 30	Aug 10
1	24.7	39.1	62.4	61.1	67.8	11.4	2.8	0.3
2	18.6	22.9	10.8	39.8	23.9	0.7	0.7	0.2
3	24.4	19.2	48.1	54.1	17.5	1.3	0.4	0.9
4	23.6	28.8	55.4	54.9	27.8	1.8	1.2	0.1
5	13.6	28.6	38.8	65.5	25.2	3.4	1.0	0.3
6	20.9	13.4	5.1	16.2	47.1	5.6	1.1	0.3
7	20.0	14.9	3.2	9.6	28.3	2.5	0.7	0.3
8	20.0	29.4	62.8	5.7	0.6	0.3	1.0	0.3
9	22.4	30.4	54.5	5.1	2.5	1.5	0.9	0.2
10	19.1	14.1	11.3	21.7	27.7	0.9	0.9	0.1

Table 12. Onion yield in response to drip or foliar applied insecticide treatment programs. 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. Programs with unregistered products are not shown. Malheur Experiment Station, Oregon State University, Ontario, OR, 2015.

Treatment number	Small		Medium		Jumbo		Colossal		Supercolossal		Marketable		Total	
	cwt/acre													
1	4.78	a	70.35	a	552.73	a	158.03	abc	5.09	c	786.20	c	801.03	bc
2	8.73	a	102.09	a	662.88	a	177.99	abc	4.42	c	947.38	ab	964.07	ab
3	4.16	a	19.40	a	572.08	a	125.18	bc	9.94	abc	726.59	c	739.02	c
4	6.04	a	131.40	a	715.88	a	181.74	ab	3.82	c	1032.84	a	1042.37	a
5	2.48	a	12.19	a	604.67	a	215.47	ab	3.82	c	836.15	bc	846.27	bc
6	3.31	a	46.88	a	521.12	a	305.83	a	28.43	ab	902.26	ab	915.02	ab
7	1.21	a	47.65	a	548.60	a	304.07	a	29.36	a	929.68	ab	940.47	ab
8	7.41	a	60.07	a	546.79	a	98.55	c	11.29	bc	716.70	c	728.71	c
9	1.39	a	14.93	a	605.34	a	221.67	ab	9.19	abc	851.13	abc	859.01	abc
10	3.20	a	12.94	a	620.11	a	220.22	ab	7.31	abc	860.58	abc	871.89	abc

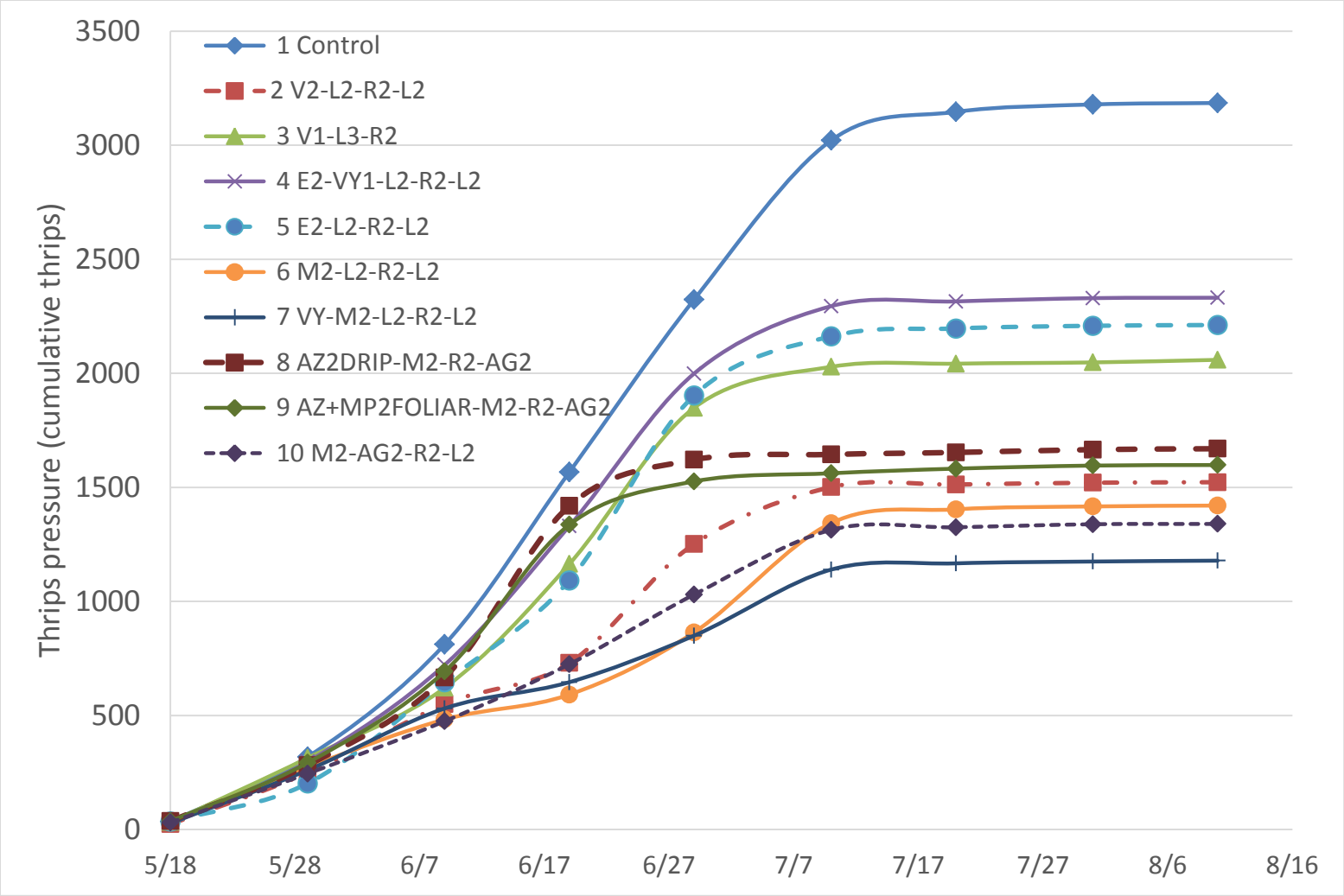

Figure 4. Cumulative thrips pressure in the drip application trial over the 2015 growing season, Malheur Experiment Station, Ontario, OR. Data are mean cumulative thrips per plot (10 plants). Smaller increases from sample date to sample date indicate better thrips control.

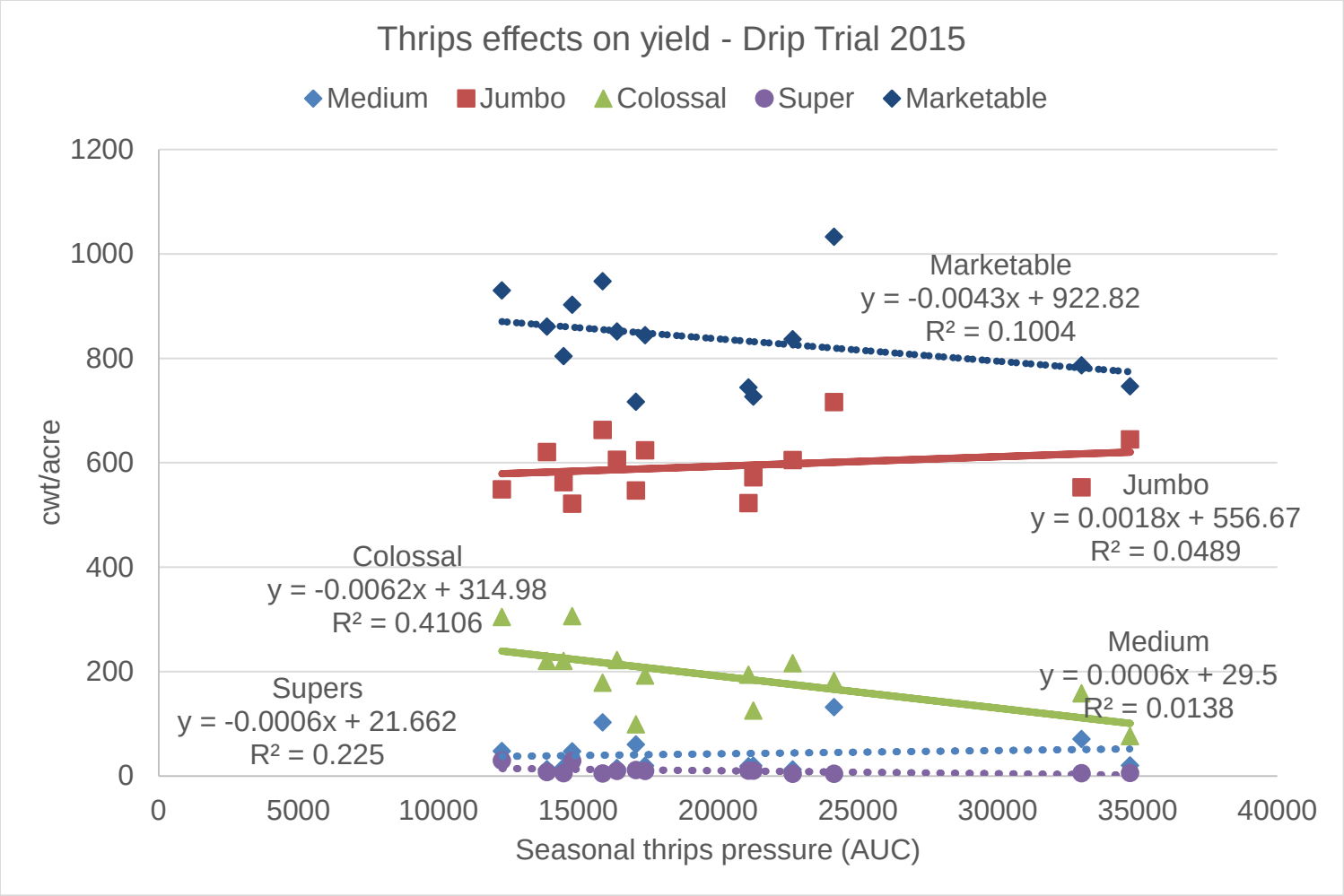

Figure 5. Effect of cumulative numbers of thrips over the growing season on onion yield. Malheur Experiment Station, Ontario, OR, 2015. As thrips pressure increases over the season, marketable yield goes down. There are also significant declines in the larger (colossal, supercolossal) size classes.