THRIPS AND *IRIS YELLOW SPOT VIRUS* MANAGEMENT IN THE TREASURE VALLEY—2019

Stuart Reitz, Ian Trenkel, Kyle D. Wieland, Erik B. G. Feibert, and Alicia Rivera, Malheur Experiment Station, Oregon State University, Ontario, OR

Objectives

Evaluate different insecticides, treatment sequences, and insecticide application methods for thrips and iris yellow spot virus management.

Introduction

Insecticides remain the primary tool for thrips and *Iris yellow spot virus* (IYSV) management. However, insecticide-based management faces difficulties because there is a limited set of registered insecticides with efficacy against onion thrips, and thrips are able to develop resistance rapidly to various classes of insecticides. Consequently, it is important to assess the effectiveness of currently registered insecticides and to determine when during the season different insecticides may be used most effectively. It is also important to determine how best to apply products so they can be effectively integrated into an overall thrips management program.

To address these objectives, we conducted two field trials to evaluate different insecticide management programs, with products applied in various sequences over the growing season. The “foliar” application trial consisted of 30 different treatment regimens with all applications made weekly (Tables 1 and 2). This trial included regimens with high and low gallonages to determine how spray volume affects efficacy of insecticides. A second trial compared treatment regimens in which products were applied by drip application. The drip application trial included 12 different treatment regimens (Tables 1 and 4), with applications made at longer (10- to 14-day) intervals than in the weekly foliar trial. Results for experimental insecticides are not shown.

PART 1. FOLIAR APPLICATION TRIAL

Materials and Methods

Cultural Practices

Onion seed (‘Vaquero’) was planted at 143,000 seeds/acre on April 1, 2019.

The field was drip irrigated with drip tape laid at 4-inch depth between two 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 (Toro Aqua-Traxx, Toro Co., El Cajon, 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 sensor model 200SS, Irrometer Co., Riverside, CA) installed throughout the field at 8-inch depth in the center of a double row. Sensors had been calibrated to SWT before placement. 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 of the Watermark sensors were connected to the WEM.

Fertility management was based on root tissue and soil analysis. Samples were taken weekly, and nutrients were injected through the drip tape as needed. Urea ammonium nitrate solution (URAN) was applied through the drip tape six times from May 30 to July 17, supplying a total of 132 lb N/acre during the growing season.

The following herbicides were applied: oxyfluorfen at 0.13 lb ai/acre (GoalTender® at 4 oz/acre), bromoxynil at 0.25 lb ai/acre (Brox® 2EC at 16 oz/acre), pendimethalin at 0.95 lb ai/acre (Prowl® H^2O at 2 pt/acre), and clethodim at 0.12 lb ai/acre (Shadow® 3EC at 5.3 oz/acre) on May 8. Pendimethalin at 0.48 lb ai/acre (Prowl H_2O at 1 pt/acre) was applied on May 31.

Foliar Insecticide Applications

Insecticides were applied weekly from June 8 to July 26, according to the schedule and rates listed in Tables 1 and 2. Each treatment plot was 4 double rows wide by 23 ft long. Insecticides were applied with a CO_2 backpack sprayer using a 4-nozzle boom with 11004 nozzles at 30 psi and 35 gal/acre. For low volume application treatments, the rate was reduced to 20 gal/acre. Treatments began once thrips counts exceeded four thrips per plant.

Data Collection

Weekly thrips counts were made, starting on May 7. Thrips counts were made by counting the number of thrips on 10 consecutive plants in one of the middle two rows of each plot 3 days after applications. Adult and larval (immature) thrips were counted separately.

Onions in each plot were evaluated visually for severity of symptoms of IYSV and thrips feeding damage on July 23 after seven of the eight insecticide treatments had been completed. Ten consecutive plants in one of the middle two rows of each plot were rated on a scale of 0 to 4 for increasing severity of symptoms or feeding damage, and their bulb diameters were measured.

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 from the middle two double rows in each plot were lifted on September 10. They were topped by hand, bagged on September 18, and placed in storage on September 24. The onions from each plot were graded on October 8, 9, 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 super colossal. Bulb counts per 50 lb of super colossal onions were determined for each plot of every variety by weighing and counting all super colossal bulbs during grading. Marketable yield consisted of No.1 bulbs in the medium or larger size classes (larger than 2¼ inches).

Results and Conclusions

Thrips adults began to colonize onions by May 8, but populations did not exceed the treatment threshold level for the trial (4 thrips per plant) until June 3. Applications in the foliar trial began on June 8. Overall, thrips pressure in the trial was higher than in 2018 but lower than in other recent years, with the greatest average number in the untreated control reaching about 41 per plant (Figure 1). Thrips populations peaked around the second week of July (July 8). Populations began to decline after that, but significant populations (~10 per plant) persisted into August after the eighth insecticide application (Table 3, Figure 2). Iris yellow spot incidence and severity were relatively low this season, with 96% of the plants having ratings of 0 (no virus) or 1 (minimal virus) (Table 2).

As is typical, the majority of thrips on onions were immatures (~80% after June 10). Because of the ability of adults to move from plant to plant, we typically do not see large differences in adult populations among insecticide treatments. The largest treatment effects are a result of the effects on immature thrips (Figures 3 and 4).

Thrips populations have a dramatic effect on marketable yield and especially on the yield of colossal and super colossal sized bulbs (Figure 5). The rate of decline in yield for the larger size classes is twice that for overall marketable yield (Figure 3). The regression lines indicate that for every additional thrips per plant per week there is a 13 cwt decrease in marketable yield and 27 cwt decrease in yields of colossal and super colossal bulbs.

The standard reference program of two applications of Movento® followed by two of Agri-Mek®, two of Radiant®, and two of Lannate® still performed well under this season's conditions (Treatment program 2). Thrips numbers increased late in the season with the final Lannate application, which was a pattern seen in other treatment programs with late season use of Lannate. Other programs where Lannate was applied earlier (e.g., Programs 14, 16, and 23) had poorer thrips control (Table 3, Figure 4).

Treatment program 10, which delayed application of Movento until the second and third applications (June 14 and June 21), had the lowest number of thrips per plant over the season and one of the highest yields (Table 2). Similar programs (e.g., programs 11 and 24) that delayed Movento applications until the third and fourth application (June 21 and June 28) also performed well by allowing Movento activity to peak when immature thrips populations were peaking (Table 3, Figure 2).

This year's trial included a number of programs with Minecto® Pro, which combines the active ingredients of Agri-Mek and Exirel®. Minecto Pro performed well whether used early or late in the season but not better than Agri-Mek, although yields with Minecto Pro tended to be slightly higher than with Agri-Mek (e.g., Treatment Programs 2 and 12 (Tables 2 and 3; Figures 4 and 5). For resistance management purposes, Minecto Pro should not be used in the same season as Agri-Mek and/or Exirel (or Verimark, the soil-applied version of Exirel).

Does GPA Make a Difference?

The volume of spray water can make a difference in insecticide efficacy. Figure 6 shows total thrips per plant for the untreated control plots and the standard program of Movento applied twice, followed by two applications of Agri-Mek, two applications of Radiant, and two applications of Lannate at 35 gallons per acre (GPA) or at 20 GPA.

The higher spray volume early in the season (applications 1–3) reduced thrips numbers by approximately 10% for each of the first three applications compared with the lower spray volume. The effect was greater as the season progressed and the plant canopy developed (applications 4–8). The fourth application was made on June 28 when the onions had reached the 6- to 7-leaf stage. For the last five applications there were 18 to 47% fewer thrips when applications were made with 35 GPA than when application were made with 20 GPA.

The size profile was greater at the high spray volume than at the lower spray volume (Figure 7). There were 18% more colossal and super colossal bulbs at 35 GPA than at 20 GPA.

Although insecticides such as Agri-Mek and Radiant move into the leaf tissue, they do not move systemically within the plant; higher spray volumes will help these types of insecticides reach the base of inner onion leaves where thrips tend to aggregate.

Does a Higher Rate of Radiant Make a Difference?

To test whether increasing rates of Radiant from 8 oz/acre to 10 oz/acre improves thrips management, we compared weekly applications of Radiant at those two rates. **(Note: Eight applications of radiant is not a labelled use.**

Thrips populations were similar for the two rates of Radiant (Figure 8). Yields were also similar, indicating that there is no benefit to increasing Radiant rates to the maximum 10 oz/acre rate (Figure 9). Please note that these applications were made at 35 GPA. At this time, we do not know if spray volume, especially low-volume aerial application, affects the efficacy of these rates.

Table 1. Characteristics of insecticides tested for efficacy against onion thrips, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019. Please consult the label to determine appropriate uses for all pesticides. Unregistered products are not listed.

Product	Company	Rate (product per acre)	Adjuvant	Active ingredient	pH	Mode of action group
Agri-Mek SC	Syngenta	3.5 fl oz	Dyne-Amic 0.25% v/v	Abamectin	6.5	6
Alluma	Sym-Agro	30–40 oz	-	Garlic oil	6.5	Unidentified (plant oil)
Aza-Direct	Gowan	16–32 fl oz	-	Azadirachtin	6.0	Unidentified
BoteGHA	Certis	0.5–1.0 qt	-	*Beauveria bassiana*	7.0	Fungal pathogen
Captiva	Gowan	7/11 fl oz	NIS 0.125% v/v (in tank mix)	Capsacin oleoresin, garlic oil, soybean oil	6.5	Unidentified (plant oil)
Cinnerate	Sym-Agro	32 fl oz	-	Cinnamon oil	6.5	Unidentified (plant oil)
Closer	Corteva	5.75 fl oz	Dyne-Amic 0.25% v/v	Sulfoxaflor	6.5	4C
Exirel	FMC	13.5–20 fl oz	Dyne-Amic 0.25% v/v	Cyantraniliprole	5.0	28
Lannate LV	Corteva	3 pt	Dyne-Amic 0.25% v/v	Methomyl	5.0	1A
Minecto Pro	Syngenta	10 fl oz	MSO 0.5% v/v or NIS 0.125% v/v	Abamectin / cyantraniliprole	6.0	6 / 28
Movento HL	Bayer	2.5 fl oz	Dyne-Amic 0.25% v/v or NIS 0.125% v/v	Spirotetramat	6.5	23
M-Pede	Gowan	5.6 pt	-	Potassium salts of fatty acids	6.0	Unidentified
Radiant	Dow	8 fl oz	Dyne-Amic 0.25% v/v	Spinetoram	7.0	5
Verimark	FMC	10.3 fl oz	-	Cyantraniliprole	5.0	28
Vydate	Corteva	2 pt	Dyne-Amic 0.25% v/v	Oxamyl	5.0	1A

Table 2. Insecticide treatment programs in the standard foliar insecticide application trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019. Average number of thrips per plant per week and marketable yield are shown in the two right-hand columns. Only treatment programs with registered products are listed. Application dates are shown in the footer at the bottom of each page.

Trt no.	Treatment name	Rate	Units/acre	Application date code	Gallonage (gal/acre)	Thrips per plant per week	Bulb diameter July 23 (inches)	IYSV rating July 23	Marketable yield (cwt/acre)
1	Untreated control					17.25	3.00	0.5	1113.99
2	Movento HL	2.5	fl oz	AB	35	10.73	3.01	0.4	1137.84
	Agri-Mek	3.5	fl oz	CD	35				
	Radiant	8	fl oz	EF	35				
	Lannate LV	3	pt	GH	35				
3	Movento HL	2.5	fl oz	AB	20	13.00	2.78	0.5	1107.56
	Agri-Mek	3.5	fl oz	CD	20				
	Radiant	8	fl oz	EF	20				
	Lannate LV	3	pt	GH	20				
4	Radiant	8	fl oz	ABCDEFGH	35	11.67	2.88	0.3	1202.75
5	Radiant	8	fl oz	ABCDEFGH	20	14.29	2.81	0.3	1175.53
6	Radiant	10	fl oz	ABCDEFGH	35	12.93	2.87	0.6	1160.76
7	Exirel	20.5	fl oz	ABCDEFGH	35	18.42	2.93	0.7	1171.79
8	Exirel	20.5	fl oz	ABCDEFGH	20	16.71	2.75	0.3	1136.38
9	Aza-Direct	16	fl oz	ABC	35	12.43	2.74	0.5	1184.40
	M-Pede	2	% v/v	ABD	35				
	Movento HL	2.5	fl oz	CD	35				
	Minecto Pro	10	fl oz	EF	35				
	Radiant	10	fl oz	GH	35				
	M-Pede	2	% v/v	GH	35				

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Trt no.	Treatment name	Rate	Units/acre	Application date code	Gallonage (gal/acre)	Thrips per plant per week	Bulb diameter July 23 (inches)	IYSV rating July 23	Marketable yield (cwt/acre)
10	Aza-Direct	16	fl oz	AB	35	9.05	2.93	0.6	1215.89
	M-Pede	2	% v/v	AC	35				
	Movento HL	2.5	fl oz	BC	35				
	Agri-Mek	3.5	fl oz	DE	35				
	Captiva	7	fl oz	DE	35				
	Radiant	10	fl oz	FG	35				
	M-Pede	2	% v/v	FG	35				
	Aza-Direct	16	fl oz	H	35				
11	Aza-Direct	16	fl oz	ABC	35	10.77	3.01	0.4	1219.99
	M-Pede	2	% v/v	ABD	35				
	Movento HL	2.5	fl oz	CD	35				
	Agri-Mek	3.5	fl oz	EF	35				
	Captiva	7	fl oz	EF	35				
	Radiant	10	fl oz	GH	35				
	M-Pede	2	% v/v	GH	35				
12	Movento HL	2.5	fl oz	AB	35	12.88	2.96	0.4	1222.24
	Minecto Pro	10	fl oz	CD	35				
	Radiant	8	fl oz	EF	35				
	Lannate LV	3	pt	GH	35				
13	Movento HL	2.5	fl oz	AB	35	11.60	3.01	0.5	1225.34
	Radiant	8	fl oz	CD	35				
	Minecto Pro	10	fl oz	EF	35				
	Lannate LV	3	pt	GH	35				

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14	Movento HL	2.5	fl oz	AB	35	13.23	2.89	0.6	1167.84
	Radiant	8	fl oz	CD	35				
	Lannate LV	3	pt	EF	35				
	Minecto Pro	10	fl oz	GH	35				
15	Movento HL	2.5	fl oz	AB	35	11.18	3.02	0.5	1242.16
	Radiant	8	fl oz	CD	35				
	Exirel	13.5	fl oz	EF	35				
	Lannate LV	3	pt	GH	35				
16	Movento HL	5	fl oz	AB	35	13.23	2.98	0.5	1163.41
	Radiant	8	fl oz	CD	35				
	Lannate LV	3	pt	EF	35				
	Exirel	13.5	fl oz	GH	35				
19	Lannate LV	3	pt	ABCDEFGH	35	16.01	2.88	0.5	1162.37
22	Radiant	8	fl oz	AB	35	18.50	2.91	0.4	1064.32
	Closer	5.75	fl oz	CD	35				
	Vydate	2	pt	EF	35				
	Agri-Mek	3.5	fl oz	GH	35				
23	Radiant	8	fl oz	AB	35	18.20	2.73	0.4	1101.56
	Lannate LV	3	pt	CD	35				
	Vydate	2	pt	EF	35				
	Agri-Mek	3.5	fl oz	GH	35				

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Trt no.	Treatment name	Rate	Units/acre	Application date code	Gallonage (gal/acre)	Thrips per plant per week	Bulb diameter July 23 (inches)	IYSV rating July 23	Marketable yield (cwt/acre)
24	Aza-Direct	16	fl oz	ABC	35	10.38	2.88	0.3	1232.40
	M-Pede	2	% v/v	AB	35				
	Movento HL	2.5	fl oz	CD	35				
	Exirel	13.5	fl oz	D	35				
	Radiant	8	fl oz	EF	35				
	Agri-Mek	3.5	fl oz	GH	35				
25	Aza-Direct	16	fl oz	AB	35	14.88	2.96	0.6	1176.68
	M-Pede	2	% v/v	AB	35				
	Movento HL	2.5	fl oz	CD	35				
	Agri-Mek	3.5	fl oz	CD	35				
	Exirel	13.5	fl oz	EF	35				
	Radiant	8	fl oz	GH	35				
26	BoteGHA ES	0.5	qt	ABCDEFGH	35	17.15	2.91	0.2	1111.52
27	BoteGHA ES	1	qt	ABCDEFGH	35	16.98	2.89	0.5	1147.59
28	Cinnerate	32	fl oz	ABCDEFGH	35	16.97	2.73	0.5	1038.54
29	Cinnerate	32	fl oz	ABCDEFGH	35	16.47	2.89	0.6	1002.91
	Alluma	30	fl oz	ABCDEFGH	35				
30	Alluma	40	fl oz	ABCDEFGH	35	17.48	2.92	0.3	1095.21

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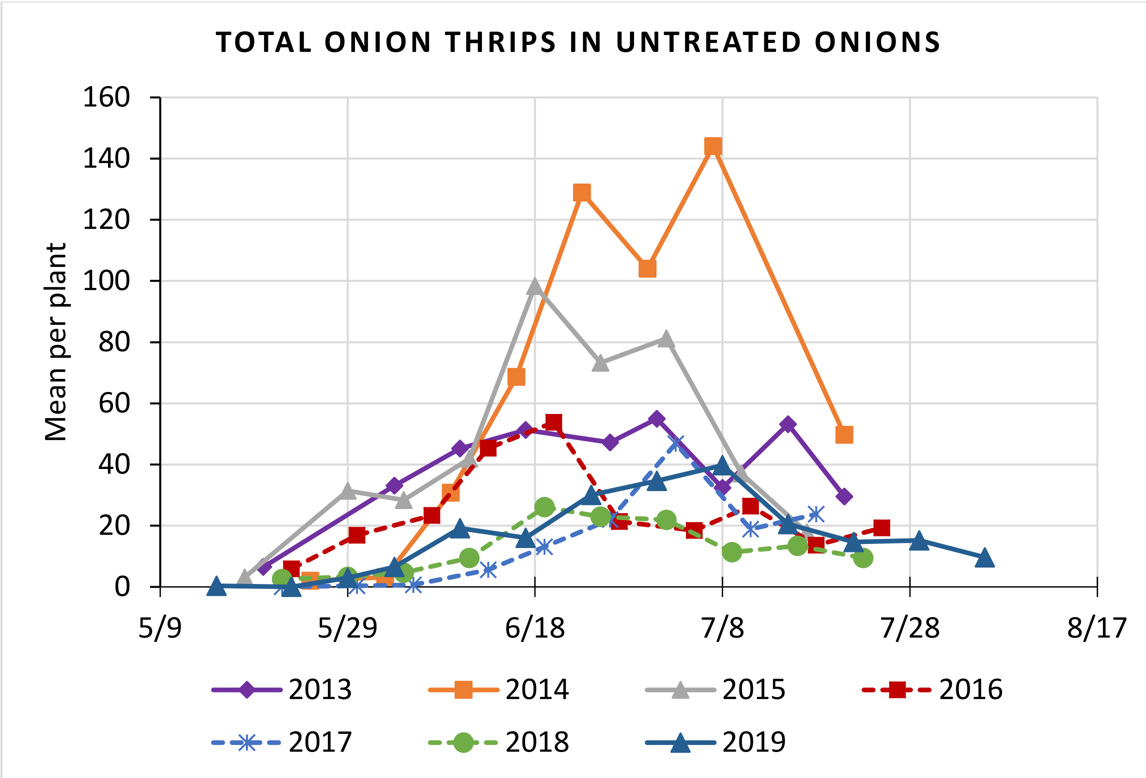

Figure 1. Total numbers of thrips per plant in untreated onion plots from 2013 to 2019 to demonstrate seasonal differences in overall thrips pressure, Malheur Experiment Station, Oregon State University, Ontario, OR

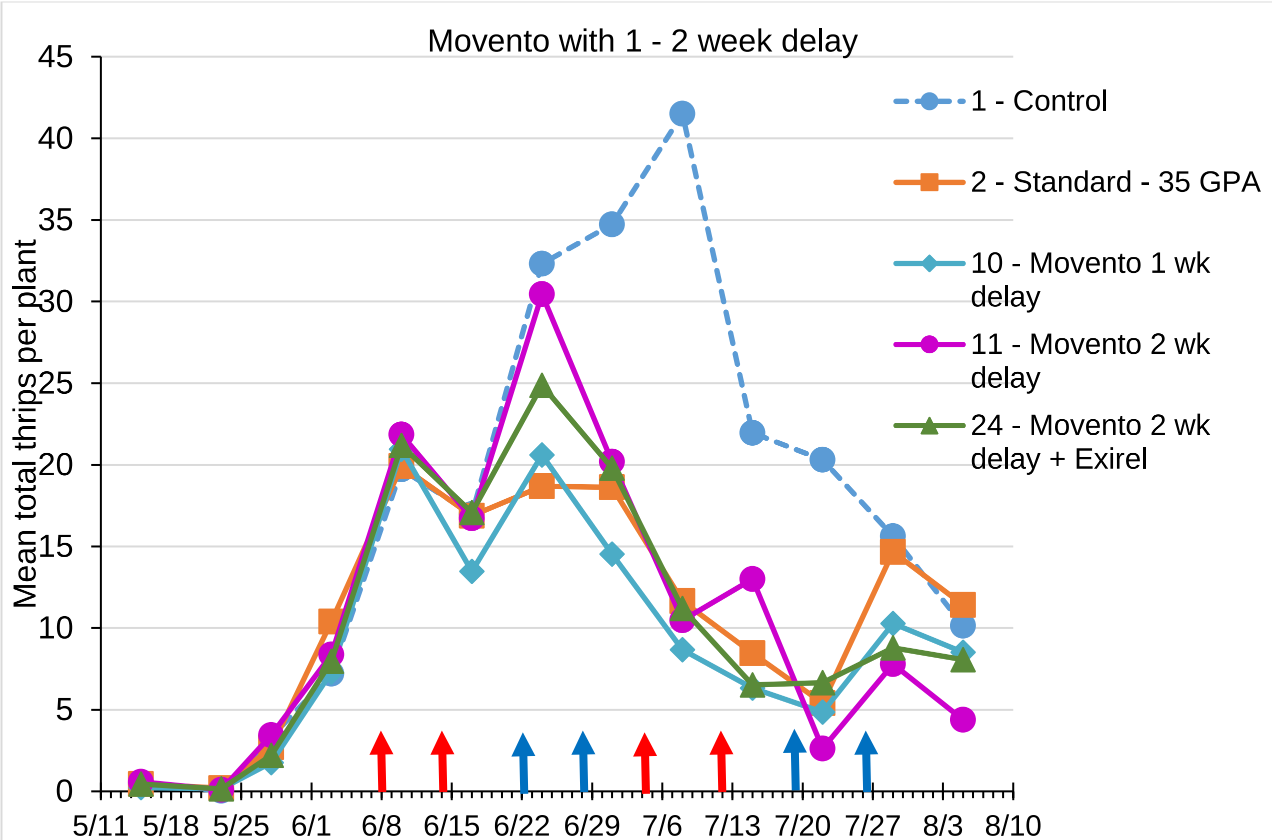

Figure 2. The effect of applying Movento at the beginning of the spray program and delaying applications by 1 to 2 weeks in the foliar application trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019. Application dates are marked by arrows on the date axis. See Table 2 for insecticides used in each program.

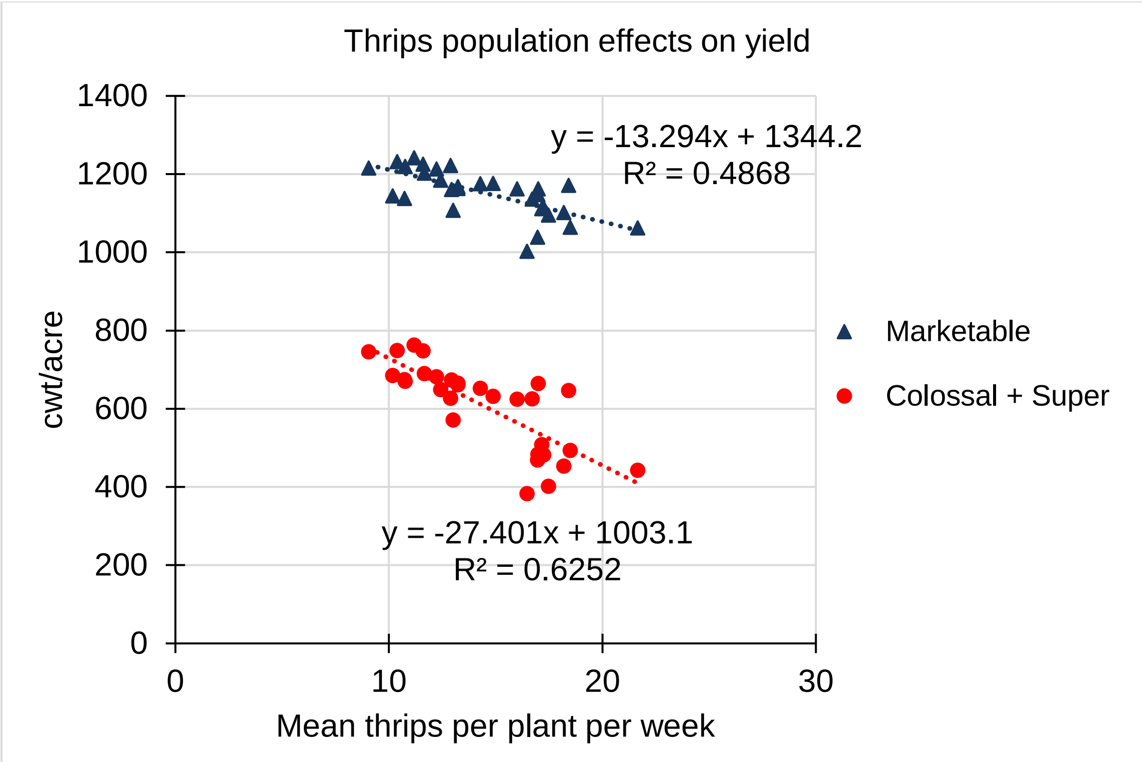

Figure 3. The effects of thrips populations on marketable yield and colossal and super colossal yields in the foliar application trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

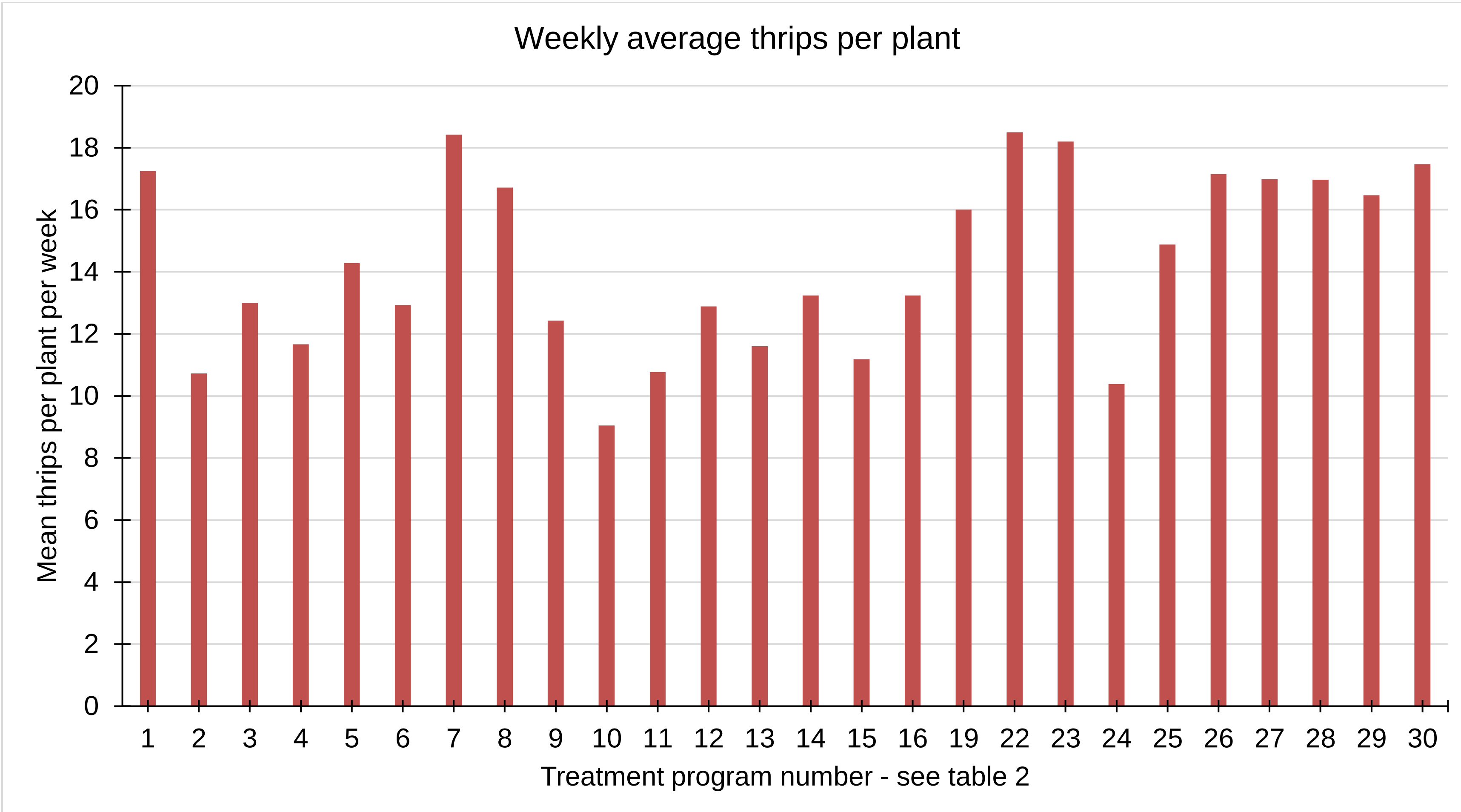

Figure 4. Mean number of thrips per plant per week in various insecticide treatment programs of the foliar application trial from May 15 to August 5, 2019, Malheur Experiment Station, Oregon State University, Ontario, OR. See Table 2 for insecticides used in each program.

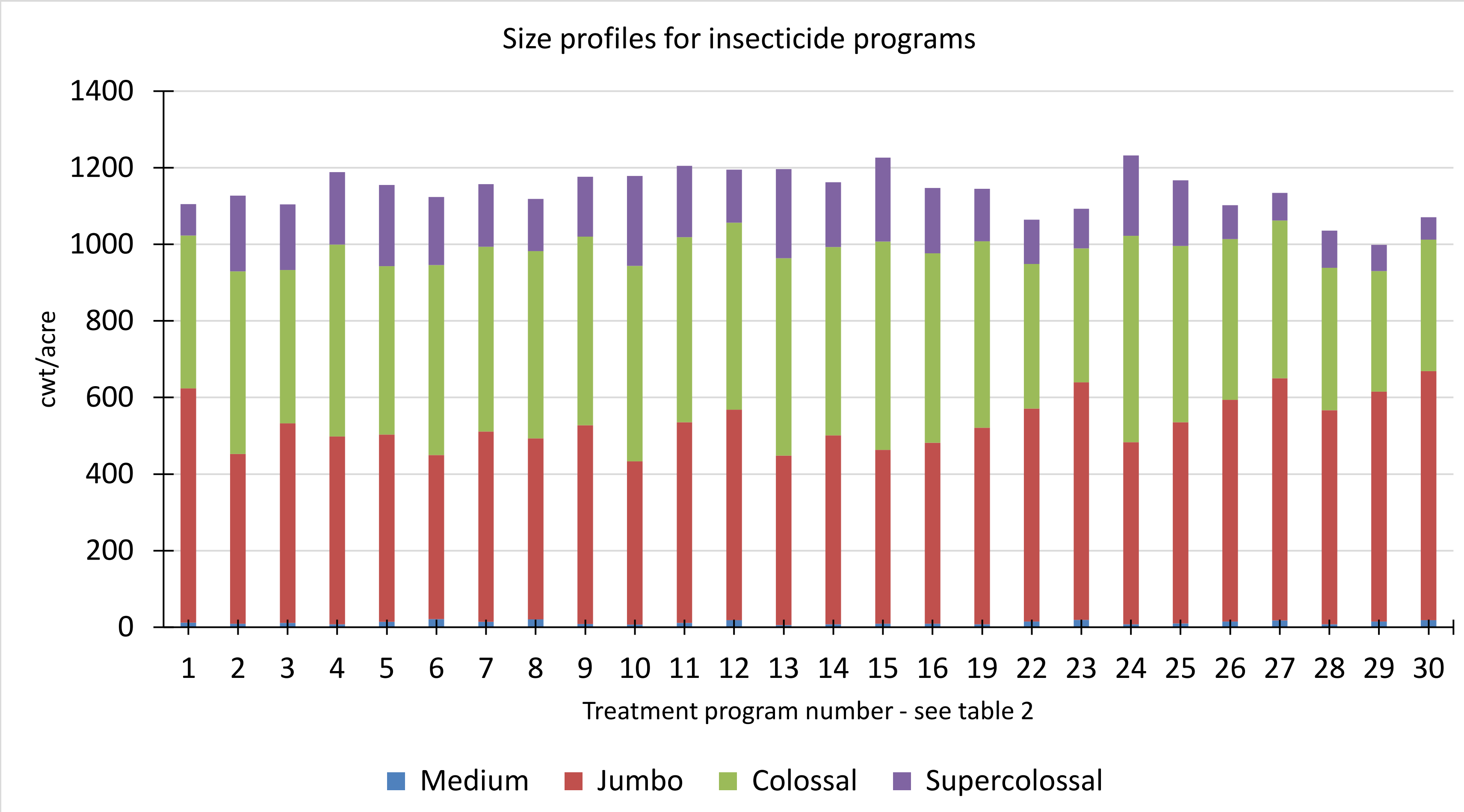

Figure 5. Bulb size profiles for various insecticide treatment programs in the foliar application trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019. See Table 2 for the insecticides used in each program.

Table 3. Mean number of thrips per plant on each sample date for various insecticide programs in the foliar application trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019. Treatment program numbers are shown in the left-hand column. See Table 2 for insecticides used in each program. The top header row indicates samples taken after each of the eight insecticide applications.

					1st	2nd	3rd	4th	5th	6th	7th	8th		
Trt	5/15	5/23	5/28	6/3	6/10	6/17	6/24	7/1	7/8	7/15	7/22	7/29	8/5	Weekly mean
1	0.5	0.0	3.3	7.2	19.7	17.0	32.3	34.7	41.5	22.0	20.3	15.6	10.2	*17.3*
2	0.5	0.2	2.7	10.4	19.9	16.9	18.7	18.6	11.7	8.5	5.4	14.7	11.4	*10.7*
3	0.2	0.2	1.8	7.8	21.5	21.4	19.5	22.8	15.2	16.0	10.0	19.9	12.7	*13.0*
4	0.4	0.3	1.0	6.9	15.1	12.9	23.0	20.8	21.1	15.1	9.3	18.7	7.0	*11.7*
5	0.5	0.1	2.4	7.9	16.1	13.6	23.3	30.6	32.1	20.3	15.3	15.9	7.6	*14.3*
6	0.3	0.6	2.6	8.1	13.9	13.5	23.1	20.4	15.4	22.1	24.8	12.3	11.2	*12.9*
7	0.4	0.3	2.8	5.4	16.0	20.1	31.4	38.8	56.1	28.2	18.3	13.1	8.8	*18.4*
8	0.6	0.1	4.3	10.1	16.1	15.9	34.4	38.2	44.2	23.7	12.8	11.2	5.7	*16.7*
9	0.4	0.3	2.2	7.7	21.9	27.8	33.4	26.0	10.2	13.6	5.1	7.2	6.0	*12.4*
10	0.2	0.2	1.8	7.3	21.0	13.5	20.6	14.5	8.7	6.3	4.9	10.3	8.5	*9.0*
11	0.6	0.1	3.5	8.4	21.9	16.7	30.5	20.2	10.5	13.0	2.6	7.8	4.4	*10.8*
12	0.5	0.5	2.1	6.5	18.8	14.9	19.5	22.5	26.5	13.5	12.4	17.2	12.9	*12.9*
13	0.4	0.3	4.7	8.6	18.5	19.2	11.5	12.5	16.0	22.0	10.0	13.2	14.1	*11.6*
14	0.3	0.2	1.9	6.2	21.3	15.7	13.7	12.0	29.3	23.1	22.6	16.1	9.8	*13.2*
15	0.3	0.1	1.9	8.7	21.6	11.4	7.8	9.7	34.1	20.5	9.6	9.6	10.2	*11.2*
16	0.4	0.1	2.9	8.9	21.0	16.9	8.8	8.5	18.4	31.3	22.9	26.1	5.9	*13.2*
19	0.5	0.2	2.4	7.6	7.1	13.2	24.5	20.7	46.5	31.1	23.7	15.9	15.0	*16.0*
22	0.4	0.1	2.4	6.1	14.1	10.1	26.7	36.5	51.9	34.7	22.3	20.3	15.2	*18.5*
23	0.7	0.3	3.5	8.3	16.4	11.2	22.6	31.7	53.5	43.0	16.7	19.6	9.1	*18.2*
24	0.5	0.2	2.2	8.0	21.2	17.1	24.9	19.8	11.2	6.5	6.7	8.8	8.1	*10.4*
25	0.3	0.2	2.0	8.0	21.3	24.9	27.9	25.5	32.0	18.0	7.6	17.8	8.2	*14.9*
26	0.4	0.1	2.2	8.3	25.9	20.7	27.3	31.2	35.9	25.3	13.5	21.3	10.9	*17.2*
27	0.6	0.2	1.8	7.7	20.8	25.9	25.2	28.6	36.1	20.3	23.9	18.9	10.9	*17.0*
28	0.3	0.0	2.3	6.2	19.7	16.6	24.9	30.9	28.8	27.8	21.7	29.3	12.4	*17.0*
29	0.3	0.3	1.9	7.0	22.5	23.7	26.2	37.8	26.2	27.2	14.1	18.2	9.1	*16.5*
30	0.6	0.1	2.9	8.4	25.9	22.4	31.9	36.4	33.0	20.4	15.0	21.5	8.9	*17.5*

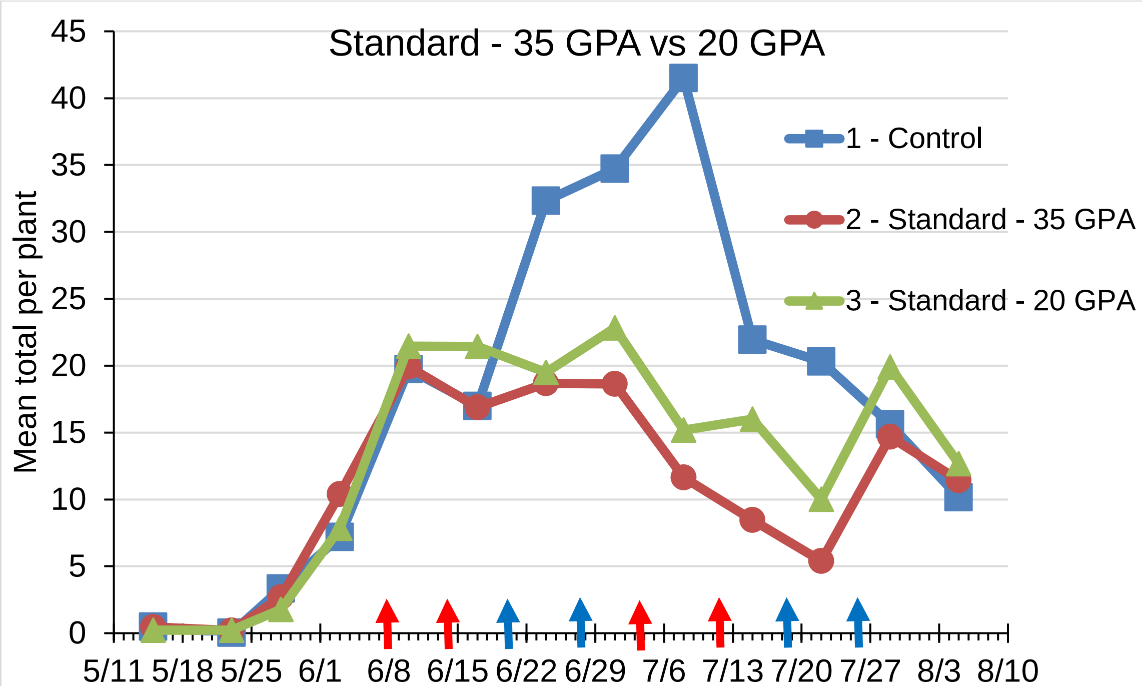

Figure 6. Comparison of high (35 GPA) and low (20 GPA) spray volumes on the average number of thrips per plant for the standard foliar spray program of Movento (2x), Agri-Mek (2x), Radiant (2x), and Lannate (2x). Malheur Experiment Station, Oregon State University, Ontario, OR, 2019. Application dates are marked by arrows along the date axis.

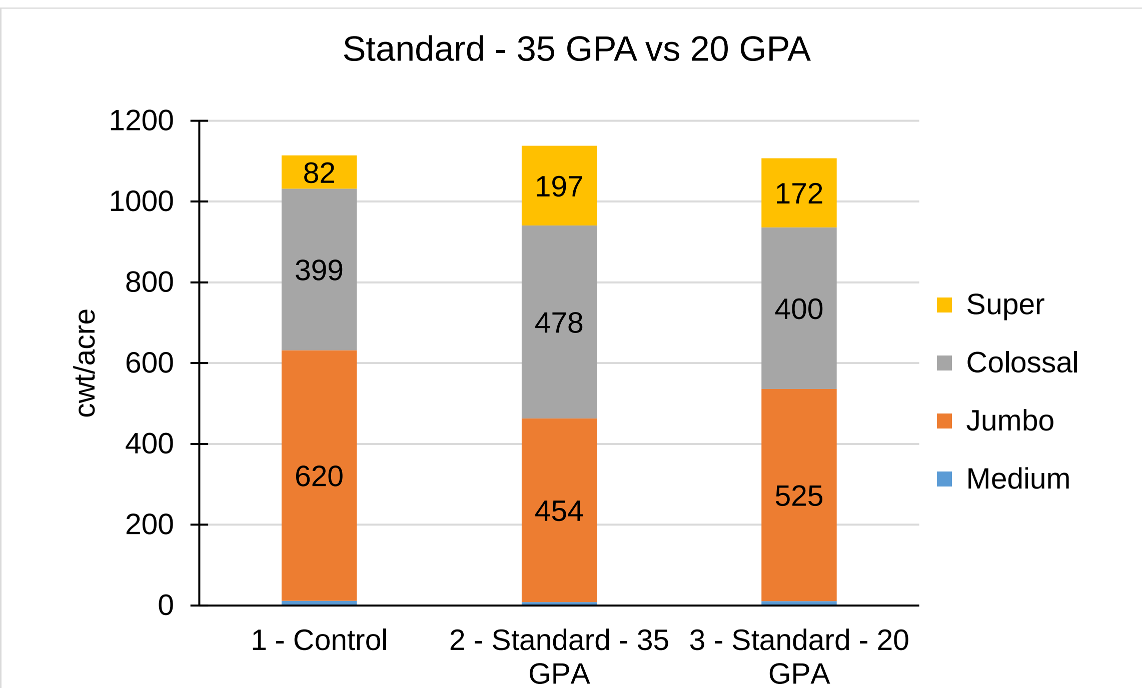

Figure 7. The effect of spray volume on bulb yield and size profile for the standard foliar insecticide program of Movento (2x), Agri-Mek (2x), Radiant (2x), and Lannate (2x). Numbers within bars are the cwt for each size class. Note how the size profile is shifted to larger size classes at 35 GPA compared with applications made at 20 GPA (60% super colossal + colossal at 35 GPA versus 52% at 20 GPA).

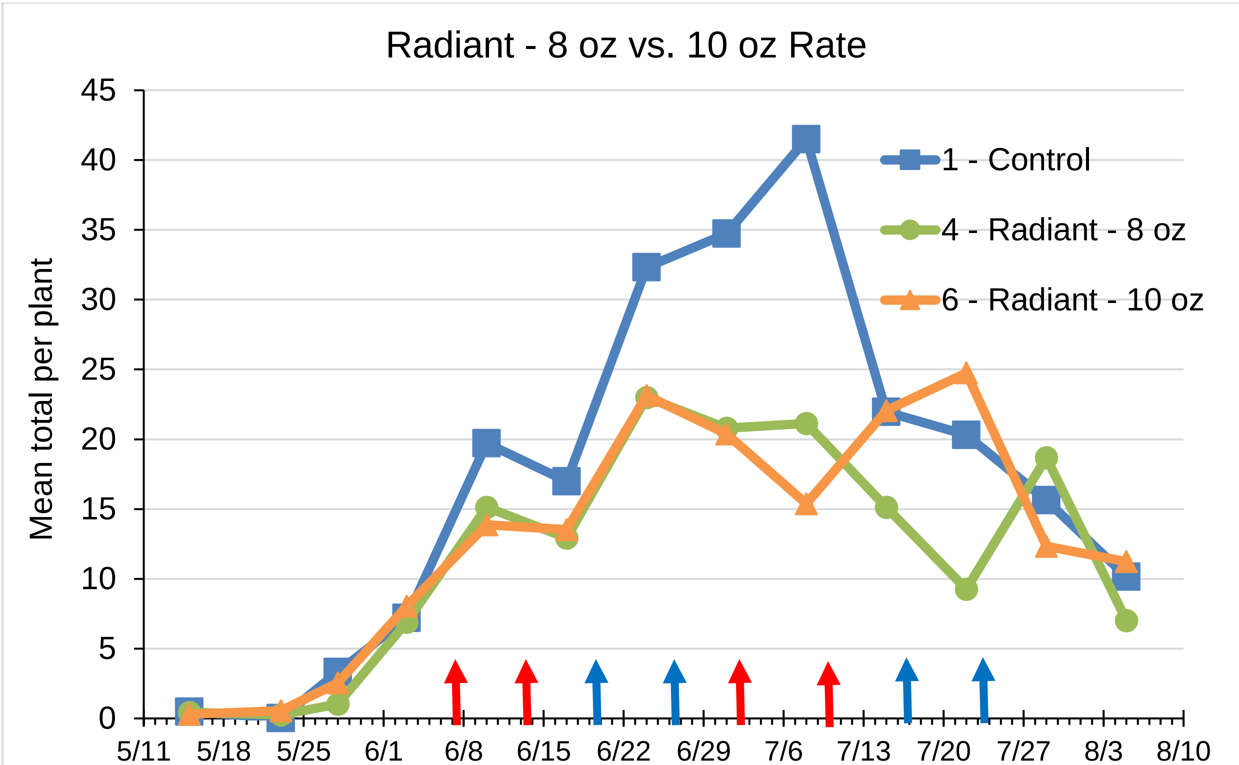

Figure 8. Comparison of thrips populations per plant with Radiant applied weekly at 8 oz/acre and at 10 oz/acre in the foliar application trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019. Application dates are marked by arrows along the date axis. Note: Eight applications of radiant is not a labelled use.

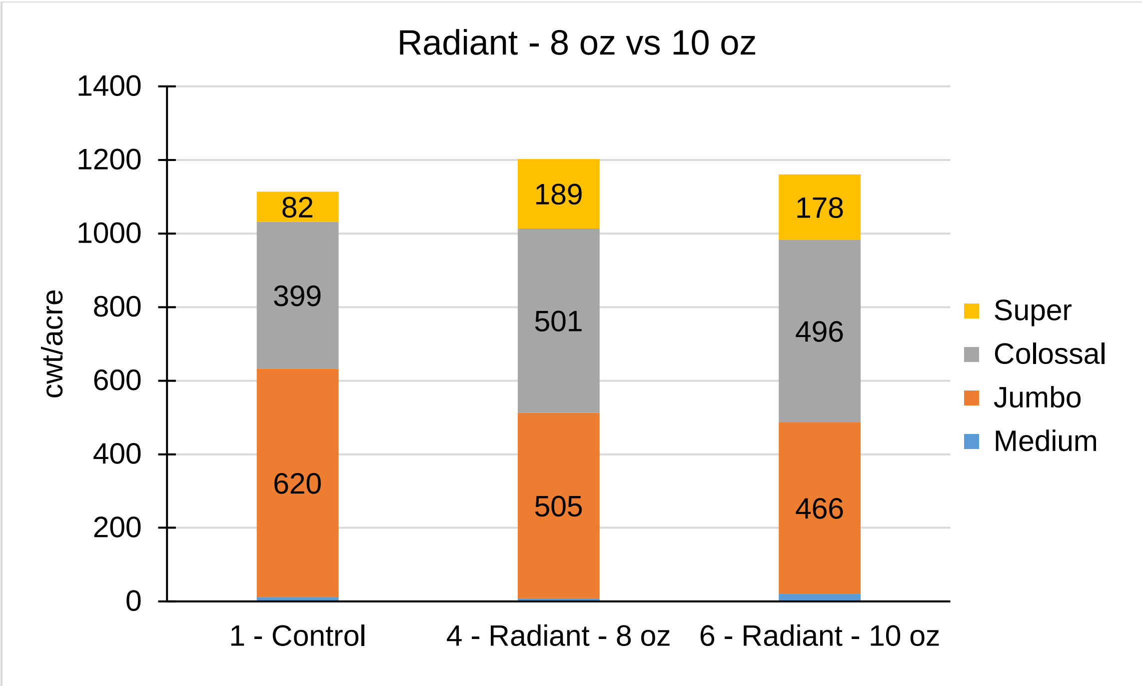

Figure 9. The effect of different rates of Radiant (8 vs. 10 oz/acre) on bulb yield and size profile in the foliar application trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019. The 10 oz rate did not improve yield. Numbers in bars are the cwt for each size class.

PART 2. DRIP APPLICATION TRIAL

Materials and Methods

Onion seed ('Vaquero') was planted at 143,000 seeds/acre on April 1, 2019.

The field was drip irrigated with drip tape laid at 4-inch depth between two 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 (Toro Aqua-Traxx, Toro Co., El Cajon, CA). The distance between the tape and the center of each double row of onions was 11 inches.

Management practices were the same as described in the foliar trial.

Applications were made on an approximately 10- to 14-day interval from June 11 to August 1 (Table 4). Only six applications were made in this longer-interval trial. The drip trial included a standard foliar program of Movento, Agri-Mek, and Radiant, similar to the standard in the 7-day foliar trial except without two final applications of Lannate (Treatment Program 2 in this trial). See Table 1 for additional product details.

Certain products were applied either through the drip irrigation system or foliar. For drip applications of insecticides, water ran for 1 hour before insecticide injections began. Each insecticide applied by drip was added to a 60-gallon tank of water that had been buffered to the appropriate pH. A pump ran each injection at 10 gallons per hour. Injections ran for 6 hours followed by 1 hour of water for a 8-hour set. Foliar applications of insecticides were made with a CO_2 powered backpack sprayer set to 30 psi and applying 35 GPA.

Data Collection

Thrips counts were made, starting on May 7. Thrips were counted on 10 consecutive plants in one of the middle two rows of each plot 3 to 4 days after insecticide applications. Adult and larval (immature) thrips were counted separately.

Onions in each plot were evaluated visually for severity of symptoms of IYSV and thrips feeding damage on August 7, after insecticide treatments had been completed. Ten consecutive plants in one of the middle two rows of each plot were rated on a scale of 0 to 4 for increasing severity of symptoms or feeding damage using the same scale as the foliar application trial, and their bulb diameters were measured.

Onions were lifted on September 10. They were topped by hand, bagged on September 18 and placed in storage on September 24. The onions from each plot were graded on October 19 and 20. 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 super colossal. Bulb counts per 50 lb of super colossal onions were determined for each plot by weighing and counting all super colossal bulbs during grading. Marketable yield consisted of No.1 bulbs in the medium or larger size classes (larger than 2¼ inches).

Results and Conclusions

Thrips exceeded the threshold of 4 per plant by June 3, but the first application was not made until June 11. Thrips populations peaked at the end of June and early July, with all treatments having 40 to 50 thrips per plant on June 27 (Figure 13). Numbers declined after that date, but large populations (>10 per plant) persisted until the sixth insecticide application on August 1.

As in the 7-day foliar trial, thrips populations significantly affected yields (Figures 10–12 and Table 4). Total marketable yield and yield of the largest size classes declined with increasing thrips numbers (Figure 11). The rate of decline was about two times greater for the larger size classes than for overall marketable yield. The regression lines indicate that for every additional thrips per plant per sample date there is a 35 cwt/acre (2%) decrease in marketable yield and 72 cwt/acre (5%) decrease in yield of colossal and super colossal bulbs. In terms of percentage loss, there was a 2% decrease in marketable yield and a 5% decrease in yield of colossal and super colossal bulbs per thrips per plant per sample date.

Treatment program 9, which consisted of foliar applications of Movento, Minecto Pro and Radiant, had the numerically highest yield and greatest proportion of colossal and super colossal onions (63% of the marketable yield). No other program had more than 56% of the marketable yield in the larger size classes (Figure 10).

Drip applications of Verimark or Aza-Direct did not improve thrips control over corresponding foliar applications of Exirel or Aza-Direct (Figures 12 and 13). It is important to note that Exirel and Verimark act as antifeedants, so thrips may still be alive on plants, but they cease feeding and causing damage. Movento is also a slow-acting insecticide, which should be considered when assessing the effectiveness of an insecticide application.

Increasing the interval between insecticide applications compromises the efficacy of insecticides for thrips management as the longer intervals allow populations to rebuild in size (compare Figures 2 and 13). Likewise, thrips management is compromised by stopping insecticide applications too early in the season. Onions remain good hosts for thrips until the time when necks begin to soften. Consider balancing the frequency of applications with the length of time needed for thrips management and the costs and benefits for your operation.

Acknowledgments

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Table 4. Insecticide treatment programs in the longer-interval drip application trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019. Average number of thrips per plant per week and marketable yield are shown in the two right-hand columns. Only treatment programs with registered products are listed. Application Date Codes: A = June 11, B = June 24, D = July 2, D = July 11, E = July 22, and F = August 1.

Trt No.	Treatment Name	Rate	Units/acre	Application Date Code	Application	Thrips per plant per sample date	Bulb diameter August 7 (inches)	IYSV rating August 7	Marketable yield (cwt/acre)
1	Untreated					14.07	3.43	0.9	1083.59
2	Movento HL	2.5	fl oz	AB	Foliar	12.46	3.21	0.8	1182.62
	Agri-Mek	3.5	fl oz	CD	Foliar				
	Radiant	10	fl oz	EF	Foliar				
4	Verimark	10	fl oz	AB	Drip	14.27	3.28	0.7	1136.55
	Lannate LV	3	pt	CD	Foliar				
	Radiant	10	fl oz	EF	Foliar				
5	Movento Hl	2.5	fl oz	AB	Foliar	14.15	3.29	1.0	1183.58
	Lannate LV	3	pt	CD	Foliar				
	Radiant	10	fl oz	EF	Foliar				
7	Movento HL	2.5	fl oz	AB	Foliar	12.39	3.38	1.0	1170.41
	Exirel	20.5	fl oz	CD	Foliar				
	Agri-Mek	3.5	fl oz	EF	Foliar				
8	Exirel	20.5	fl oz	AB	Foliar	12.12	3.36	1.0	1140.38
	Movento HL	2.5	fl oz	CD	Foliar				
	Aza-Direct	16	fl oz	CD	Foliar				
	Radiant	10	fl oz	EF	Foliar				
9	Movento HL	2.5	fl oz	AB	Foliar	10.96	3.21	0.6	1249.35
	Minecto Pro	10	fl oz	CD	Foliar				
	Radiant	10	fl oz	EF	Foliar				
10	Aza-Direct	32	fl oz	ABCD	Drip	13.50	3.12	1.1	1068.37
	Movento HL	2.5	fl oz	CD	Drip* Not registered use				
	Verimark	10	fl oz	EF	Drip				

Table 4. Insecticide treatment programs in the longer-interval drip application trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019. Average number of thrips per plant per week and marketable yield are shown in the two right-hand columns. Only treatment programs with registered products are listed. Application Date Codes: A = June 11, B = June 24, D = July 2, D = July 11, E = July 22, and F = August 1.

Trt No.	Treatment Name	Rate	Units/acre	Application Date Code	Application	Thrips per plant per sample date	Bulb diameter August 7 (inches)	IYSV rating August 7	Marketable yield (cwt/acre)
11	Aza-Direct	16	fl oz	ABCD	Foliar	11.29	3.30	0.9	1121.43
	M-Pede	2	% v/v	AB	Foliar				
	Movento HL	2.5	fl oz	CD	Foliar				
	Exirel	20.5	fl oz	EF	Foliar				
12	Aza-Direct	32	fl oz	AB	Drip	12.88	3.22	1.0	1067.73
	Verimark	10	fl oz	CD	Drip				
	Radiant	10	fl oz	EF	Foliar				

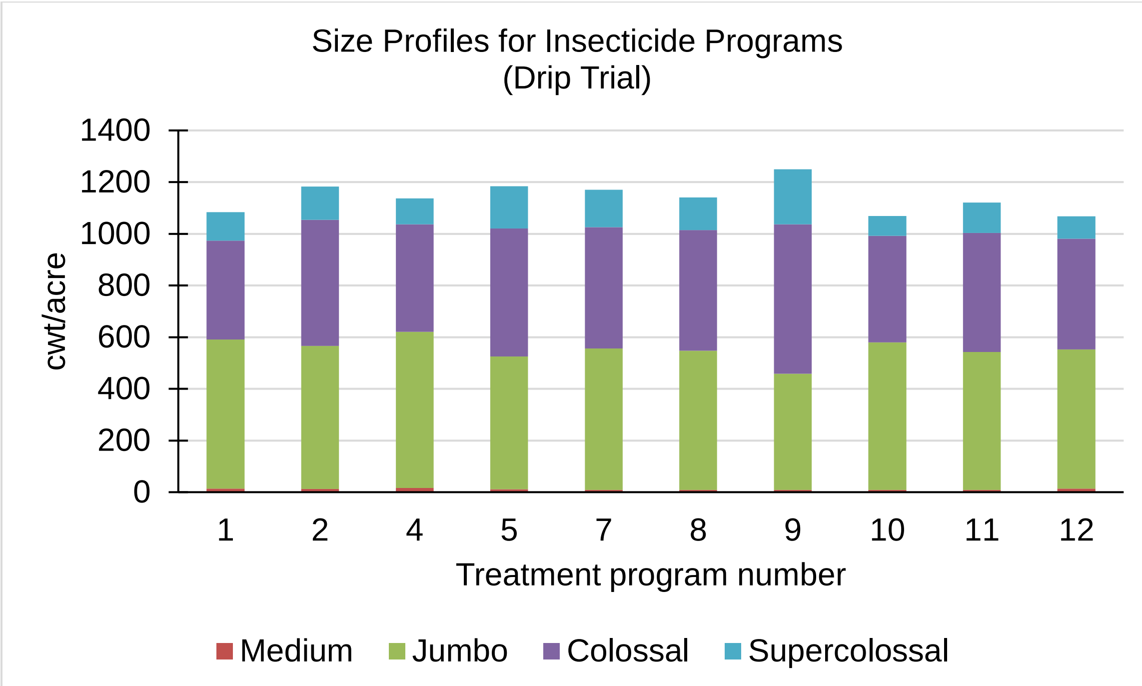

Figure 10. Bulb size profiles for various insecticide treatment programs in the drip application trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019. See Table 4 for the insecticides used in each program.

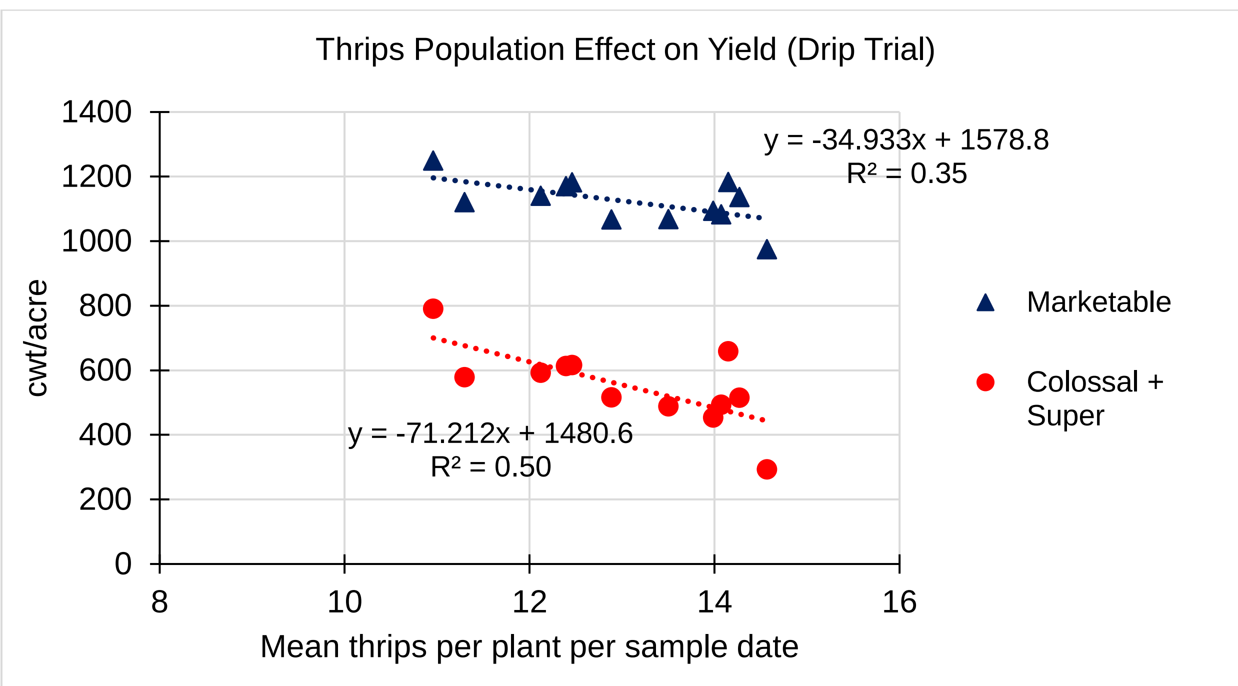

Figure 11. The effects of thrips populations on marketable yield and colossal and super colossal yields in the drip application trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

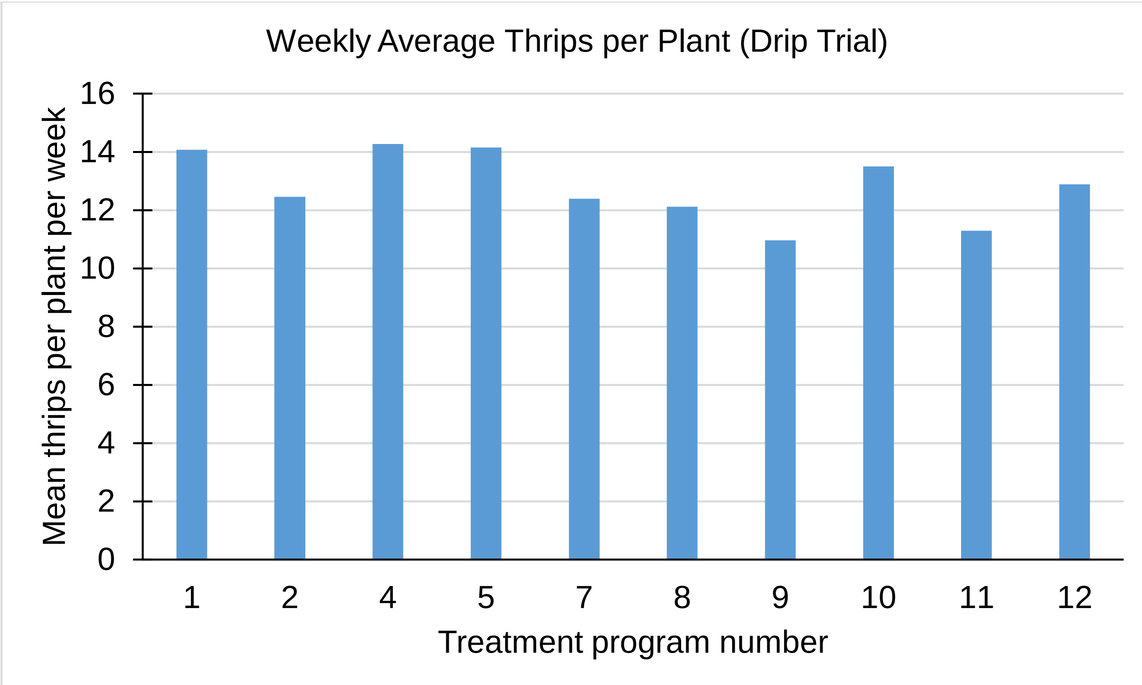

Figure 12. Mean number of thrips per plant per sample date in various insecticide treatment programs from May 15 to August 5, 2019 in the drip application trial, Malheur Experiment Station, Oregon State University, Ontario, OR. See Table 4 for the insecticides used in each program.

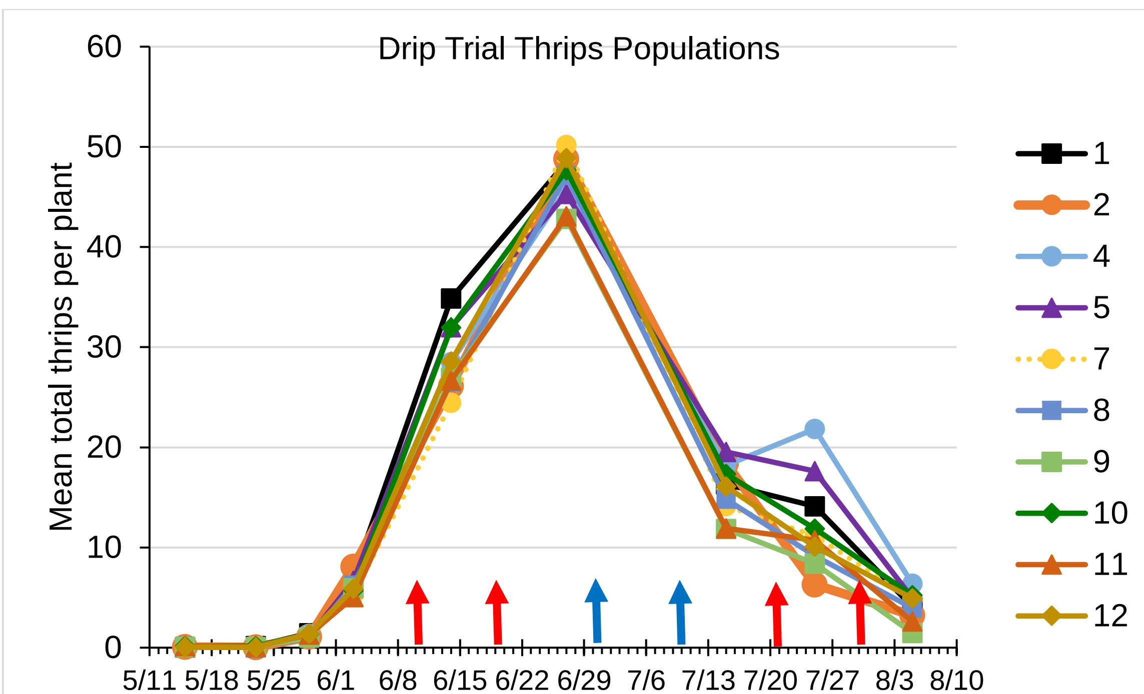

Figure 13. Comparison of thrips populations per plant in various insecticide treatment programs in the drip application trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019. Application dates are marked by arrows along the date axis. See Table 4 for insecticides used in each program.