

**Research Abstract for the
CALIFORNIA LEAFY GREENS RESEARCH PROGRAM
April 1, 2012 – March 31, 2013**

Project Title: Management of Thrips on Lettuce

Project Investigator: Eric T. Natwick
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Summary: Western flower thrips, *Frankliniella occidentalis* (Pergande), (WFT) is a damaging, cosmopolitan pest, resistant to many insecticides worldwide and causes serious economic losses to lettuce growers and other leafy green vegetable crops in California annually. Two trials were conducted to evaluate the efficacy of commercial and experimental insecticides for thrips control in iceberg lettuce and romaine lettuce. Although several efficacious insecticides are registered for thrips control on both types of lettuce, new and efficacious insecticidal chemicals with novel modes of action are needed to slow the development of thrips-resistance to insecticides. New insecticides with novel modes of action are needed to help maintain insecticide susceptibility in WFT populations; insecticide resistance management (IRM). There is also a need to explore use patterns of insecticides that are safe and efficacious against thrips in leafy greens.

All insecticide treatments were effective in reducing WFT populations compared to the non-treated check plots in both experiments. Standard insecticides (Radiant and Lannate) were among the best thrips control treatments. Aza-Direct used in combination with M-Pede and Gladiator Insecticide (zeta-cypermethrin and Abamectin B1) used alone had some activity against western flower thrips, but were among the least efficacious. Torac 15EC (tolfenpyrad) under development by Nichino had good activity against WFT. New biological insecticide, Grandevo and MBI-206, showed some activity against WFT in combinations with other insecticides. Closer (sulfoxaflor) is a new insecticide under development by Dow AgroSciences that had some activity against WFT used alone or in combination with other insecticides. All of the aforementioned products are important because they represent different chemical class modes of action (MOA) according to the Insecticide Resistance Action Committee (IRAC). When registered, they can be used in rotation to help maintain WFT susceptibility in California. Radiant is a Spinosyn (Group 5), nicotinic acetylcholine receptor agonists. Lannate is a carbamate (Group 1A), Gladiator contains two active ingredients (a.i.) a pyrethroid insecticide (zeta-cypermethrin, Group 3A) a sodium channel modulator and Avermectin B1 (Group 6) is a chloride channel modulator affecting nerve and muscle action. Aza-Direct is azadirachtin (Group UN) and M-Pede is potassium salts of fatty acids that disrupt cell membranes. In addition to the aforementioned insecticides representing seven different MOAs, new insecticides under development representing two additional MOAs were evaluated. Closer, a.i. sulfoxaflor is in another IRAC mode of action chemical class, (Group 4C) a nicotinic acetylcholine agonist/antagonists. Torac 15EC, a.i. Tolfenpyrad (Group 21A), a mitochondrial complex I electron transport inhibitors under development by Nichino America, also shows promise as a thrips control insecticide that could be used in rotation with insecticides in other IRAC groups for IRM. All of the aforementioned insecticidal formulated products have a potential use for protecting leaf greens from thrips and for IRM of Western flower thrips.

**PROJECT REPORT TO THE
CALIFORNIA LEAFY GREENS RESEARCH PROGRAM
April 1, 2010 – March 31, 2011**

Project Title: Management of Thrips on Lettuce

Project Investigator: Eric T. Natwick
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Introduction:

The western flower thrips, *Frankliniella occidentalis* (Pergande), (WFT) is a common pest in lettuce grown in the low desert region, and can cause serious economic losses to lettuce growers. Two trials were conducted to evaluate the efficacy of commercial and experimental insecticides for thrips control in iceberg lettuce and romaine lettuce.

Objectives:

The immediate objectives are to assess the efficacy of insecticides for management of western flower thrips in iceberg head lettuce and romaine lettuce.

Materials and Methods:

Site location:	University of California Desert Research and Extension Center, 1004 Holton Road, El Centro, CA 92243
Host Crop:	Romaine, var. Sunbelt and Iceberg Lettuce, var. Jupiter
Planting date:	22 October for romaine and 23 October 2012 for iceberg
First irrigation:	23 October for romaine and 24 October for iceberg
Soil type:	Holtville silty clay, wet
Cultural practices:	Romaine and iceberg lettuce seeds were sown in 2 seed-lines on 40 inch raised beds, sprinkler irrigated to emergence; furrow irrigated thereafter
Herbicide:	Prefar 4-E pre-emergence @ 6 qt/acre & Kerb SC at emergence @ 2 pt/acre
Experimental Design:	Randomized complete block
Replication and Units:	4 replicates of 50' x 13.3' (4 beds/plot)
Ground Applications:	Lee Spider Spray Tractor 4-row sprayer with three nozzles per row delivering 53 gpa at 30 psi

Insecticide application rates and application dates for each experiment are listed in Tables 1 & 2.

Table 1. List of Treatments and Rates for Thrips Control in Iceberg Lettuce 2013.

Treatment	Rate/acre	Treatment date
1. MustangMax f/b Lannate LV	4.0 fl oz 40.0 fl oz	11 Jan, 1 Feb 22 Jan
2. Aza-Direct + M-Pede	1.5 pt 2% v/v	11, 22 Jan, 1 Feb
3. Aza-Direct + M-Pede	2.0 pt 1% v/v	11, 22 Jan, 1 Feb
4. Radiant	7.0 fl oz	11, 22 Jan, 1 Feb
5. Closer SC	2.0 fl oz	11, 22 Jan, 1 Feb
6. Closer SC r/w Radiant SC	2.0 fl oz 7.0 fl oz	11 Jan, 1 Feb 22 Jan
7. Closer SC r/w Radiant SC r/w Lannate LV	2.0 fl oz 7.0 fl oz 36.0 fl oz	11 Jan 22 Jan 1 Feb
8. Radiant + Grandevo	7.0 fl oz 1.0 lb	11, 22 Jan, 1 Feb
9. Closer SC + Grandevo	2.0 fl oz 1.0 lb	11, 22 Jan, 1 Feb
10. Radiant + MBI-206	7.0 fl oz 1.0 gal	11, 22 Jan, 1 Feb
11. Closer SC + MBI-206	2.0 fl oz 1.0 gal	11, 22 Jan, 1 Feb
12. Torac 15EC f/b Radiant f/b Lannate LV	21.0 fl oz 7.0 fl oz 36 fl oz	11 Jan 22 Jan 1 Feb
13. Torac 15EC + Lannate LV r/w Radiant	21.0 fl oz 36.0 fl oz 7.0 fl oz	11 Jan, 1 Feb 22 Jan
14. Check	-----	-----

Dyne-Amic @ 0.25% vol/vol (37.9 ml/4 gal) added to foliar spray mixtures.

Table 2. Treatments and Rates in Romaine Lettuce 2013.

Treatment	Rate/acre	Trt. date
1. Radiant f/b Lannate LV f/b Aza-Direct	8 fl oz 36 fl oz 2 pt	11 Jan, 11 Feb 22 Jan 1 Feb
2. Lannate LV r/w Radiant	36 fl oz 7 fl oz	11 Jan, 1 Feb 22 Jan, 11 Feb
3. Radiant	7.0 fl oz	11, 22 Jan, 1, 11 Feb
4. Torac 15EC f/b Radiant f/b Lannate LV f/b Torac 15EC	21.0 fl oz 7.0 fl oz 36 fl oz 21.0 fl oz	11 Jan 22 Jan 1 Feb 11 Feb
5. Torac 15EC + Lannate LV r/w Radiant	21.0 fl oz 36.0 fl oz 7.0 fl oz	11 Jan, 1 Feb 22 Jan, 11 Feb
6. Gladiator	10 fl oz	11, 22 Jan, 1, 11 Feb
7. Gladiator	14 fl oz	11, 22 Jan, 1, 11 Feb
8. Gladiator	19 fl oz	11, 22 Jan, 1, 11 Feb
9. Aza-Direct + M-Pede	2.0 pt 2% v/v	11, 22 Jan, 1, 11 Feb
10. Radiant SC r/w Movento r/w Lannate LV	8.0 fl oz 5.0 fl oz 36.0 fl oz	11 Jan, 11 Feb 22 Jan 1 Feb
11. Check	-----	-----

*Dyne-Amic @ 0.25% vol/vol (37.9 ml/4 gal) added to foliar spray mixture.

Evaluations:

Iceberg lettuce evaluations were conducted on 9, 14, 18, 22 and 30 January, 4 and 8 February 2013 or pre-treatment, 3 days after application (DAA) 1, 7DAA1, 11DAA1, 8DAA2, 3DAA3, 7DAA3, 10DAA3 and for romaine lettuce on 7, 14, 18, 22, and 31 January, 2, 4, 8, 14 and 19 February 2013 or pre-treatment, 3DAA1, 7DAA1, 11DAA1, 8DAA2, 3DAA3, 7DAA3, 10DAA3, 3DAA4, 8DAA4. During each evaluation, 5 lettuce plants were extracted, placed in plastic bags labeled with sampling date and plot number and transported to the laboratory where thrips larvae and adults were separated from lettuce heads via washing in a surfactant solution and removed with a sieve. Extracted WFT larvae and adults were placed in vials of EtOH, labeled with the plot number and sampling date until they could be tallied using a binocular

microscope, and number of larvae and adults were recorded (Tables 3 – 5 for iceberg and Tables 7-9 for romaine).

Harvest data were collected from 13.1 row feet of each plot (0.001 acre) for each experiment; on 13 February for iceberg lettuce and on 20 February for romaine lettuce. The numbers of marketable naked iceberg lettuce heads and the numbers of marketable romaine hearts were recorded. All whole romaine lettuce heads were too thrips damaged to be marketable, so only romaine hearts were evaluated as market quality or as culls caused by thrips damage. Thrips damaged iceberg lettuce heads and thrips damaged romaine hearts were tallied. The total numbers and weight of marketable iceberg lettuce heads and total numbers of marketable romaine hearts were recorded for each plot in each experiment. The percentages of marketable iceberg lettuce heads and the percentages of marketable romaine hearts were determined for each insecticide treatment in each experiment (Tables 6 & 10).

Statistical analysis:

Raw data for each experiment were analyzed using ANOVA. Differences among means on each sampling date and in each experiment were determined using Least Significant Difference Test ($P=0.05$).

Results and Discussion:

The levels of WFT were very high for both the iceberg lettuce and the romaine lettuce experiments. All of the test products were effective in significantly reducing ($P=0.05$) populations of WFT adults and larvae, compared to the non-treated check plots for both the iceberg and romaine lettuce experiments on at least some of the sampling dates (Tables 3 – 5 & 7-9). In the iceberg lettuce experiment, all insecticide treatments had significantly fewer WFT larvae than the check on all post-treatment sampling dates except 18 January 7DAA1 (Table 3). Radiant used alone had the lowest post-treatment average (PTA) for thrips larvae in iceberg lettuce, Radiant used alone had only the third lowest post-treatment average (PTA) for thrips adults in iceberg lettuce (Table 4), and Radiant alone was the most efficacious insecticide based on the PTA for all thrips (Table 5); however, rotation with other insecticides of differing IRAC MOA are needed for IRM. The treatment of Torac + Lannate rotating with Radiant was the most efficacious rotation treatment for control of thrips larvae on iceberg lettuce, the second most efficacious treatment against adult thrips and the second most efficacious treatment for PTA of thrips adults plus larvae (Tables 5). The treatment with Aza-Direct @ 32 fl oz/acre plus M-Pede @ 1% vol/vol was the least efficacious insecticide treatment for both thrips larvae and thrips adults in the iceberg lettuce experiment; however, this treatment did provide WFT control and could be used in rotation with other thrips control insecticides for IRM.

In the romaine experiment, all insecticide rotation treatments that included Radiant and Lannate were more efficacious than Radiant alone for control of WFT larvae (Tables 7), Radiant used alone was only the fifth most efficacious treatment for adults thrips behind two other treatments that included rotations of Torac, Radiant and Lannate and a rotation of Lannate and Radiant (Table 8), and Radiant used alone was only the fourth lowest mean for the PTA of the combination of thrips larvae and adults (Table 9) The most efficacious treatments were Torac + Lannate rotating with Radiant and the rotation of Torac, Radiant and Lannate with the two lowest PTA for WFT larvae and adults combined. The least efficacious treatment for WFT control in the romaine lettuce experiment was the combination of Aza-Direct + M-Pede;

however, this treatment did provide control of WFT and could be used in a rotation with other insecticides for IRM.

All of the insecticide treatments had more market quality iceberg lettuce heads, fewer thrips damaged heads, and significantly ($P=0.05$) higher percentages of marketable heads than the non-treated check plots for iceberg lettuce (Table 6). In the romaine lettuce experiment, all of insecticide treatments had more market quality romaine hearts; significantly fewer thrips damaged romaine hearts and significantly higher percentages of marketable romaine hearts than the non-treated check (Table 10). In the romaine experiment, all of the insecticide treatments had significantly higher means weights in kg of romaine hearts than the non-treated check.

Not surprisingly, treatment that included industry standards such as Radiant, or Lannate performed well against WFT larvae and adults as they have in earlier experiments in 2005, 2006, 2009 and 2011. Torac is an insecticide that should receive a lettuce label in California during this year or next and will be a valuable addition for thrips control and for IRM. Grandevo TM is a microbial-based insecticide based upon the novel bacterium *Chromobacterium subtsugae* strain PRAA4-1T recently registered for use on leafy vegetables by Morrone Bio Innovations. Further research is needed to determine how useful Grandevo will be as a standalone treatment against thrips on leafy vegetables. MBI-206 is not registered for use on vegetable crops. MBI-206 (*Burkholderia* sp. strain A396) another biological insecticide under development by Morrone Bio Innovations that may be useful for WFT control when labeled for use on leafy vegetables. More research is needed with MBI-206 to evaluate WFT control for leafy vegetable production. All of the insecticides tested have a fit in a lettuce IPM and IRM program, if and when they are registered for this use. It is vitally important that rotation of insecticide groups by IRAC group numbers be practiced to slow the development of insecticide-resistant WFT. Dow AgroSciences is not interested in development of Closer a.i. sulfoxaflor for thrips control on leafy vegetables at this time. Closer is likely to receive a federal registration with a label that includes use on vegetable crops sometime during 2013, but will Closer will not receive a California label for at least two more years. FMC Corporation does not intend to sell Mustang Max in California, but a similar product, Mustang Insecticide is available for use on leafy vegetables in California.

Table 3. Western Flower Thrips Larvae per Five Iceberg Lettuce Plants at Holtville, CA 2013.

Treatment	Oz/acre	PT ^x	3DAA ^y 1	7DAA1	11DAA1	8DAA2	3DAA3	7DAA3	10DAA3	PTA ^z
MustangMax f/b Lannate LV	4.0 fl 40.0 fl	399.5 a	229.0 b	281.8 a	246.0 b-d	242.3 bc	166.5 b-e	134.5 bc	151.8 cd	207.4 c-e
Aza-Direct + M-Pede	24.0 fl + 2% v/v	417.0 a	274.3 b	263.3 a	231.3 b-d	246.8 bc	297.8 b	151.5 b	189.0 c	236.3 bc
Aza-Direct + M-Pede	32.0 fl + 1% v/v	364.5 a	270.8 b	190.0 a	280.5 a-c	322.3 ab	277.8 bc	247.3 a	329.5 b	274.0 bc
Radiant	7.0 fl	331.5 a	191.5 b	224.8 a	173.8 d	97.0 d	67.3 e	68.0 c	40.3 e	123.2 g
Closer SC	2.0 fl	358.8 a	265.3 b	242.3 a	244.5 b-d	256.3 bc	251.0 b-d	150.3 b	129.5 c-e	219.9 bc
Closer SC r/w Radiant SC	2.0 fl 7.0 fl	360.8 a	286.8 b	330.0 a	280.5 a-c	177.8 cd	173.8 b-e	129.3 bc	92.5 c-e	210.1 cd
Closer SC r/w Radiant SC r/w Lannate LV	2.0 fl 7.0 fl 36.0 fl	430.5 a	276.0 b	320.8 a	308.0 ab	224.8 b-d	167.5 b-e	108.5 bc	109.3 c-e	216.4 cd
Radiant + Grandevo	7.0 fl +16.0 dry	401.8 a	246.0 b	196.5 a	243.5 b-d	129.8 cd	143.5 c-e	88.5 bc	75.3 de	160.4 d-g
Closer SC + Grandevo	2.0 fl +16.0 dry	331.8 a	213.5 b	206.3 a	221.0 cd	186.0 cd	159.8 b-e	131.8 bc	159.3 cd	182.5 c-f
Radiant + MBI-206	7.0 fl +128.0 fl	417.0 a	254.8 b	246.3 a	230.8 b-d	106.0 d	117.8 de	64.5 c	46.8 e	152.4 e-g
Closer SC + MBI-206	2.0 fl +128.0 fl	367.0 a	234.0 b	180.8 a	221.0 cd	254.3 bc	145.8 c-e	131.0 bc	102.8 c-e	181.4 c-f
Torac 15EC f/b Radiant f/b Lannate LV	21.0 fl 7.0 fl 36 fl	334.5 a	221.0 b	266.0 a	232.3 b-d	173.0 cd	108.0 de	71.0 c	72.3 de	163.4 d-g
Torac 15EC + Lannate LV r/w Radiant	21.0 fl + 36.0 fl 7.0 fl	401.3 a	268.3 b	204.5 a	182.8 d	102.8 d	75.8 e	64.3 c	69.5 de	138.3 fg
Untreated Check	-----	346.5 a	451.0 a	403.0 a	351.0 a	442.5 a	560.5 a	283.5 a	531.3 a	431.8 a

Means within columns followed by the same letter are not significantly different LSD; $P = 0.05$

^x PT = pre-treatment. ^y DAA = days after application. ^z PTA = post treatment average.

Table 4. Western Flower Thrips Adults per Five Iceberg Lettuce Plants at Holtville, CA 2013.

Treatment	Oz/acre	PT ^x	3DAA ^y 1	7DAA1	11DAA1	8DAA2	3DAA3	7DAA3	10DAA3	PTA ^z
MustangMax f/b Lannate LV	4.0 fl 40.0 fl	174.5 a	78.5 d	160.5 d-g	115.8 cd	136.3 a	95.8 c	78.0 a	105.0 a	110.0 h
Aza-Direct + M-Pede	24.0 fl + 2% v/v	156.0 a	109.5 cd	140.3 e-g	131.3 b-d	149.0 a	139.3 bc	104.0 a	123.8 a	128.1 e-h
Aza-Direct + M-Pede	32.0 fl + 1% v/v	226.8 a	147.8 bc	243.0 a-c	175.0 ab	217.8 a	141.8 bc	186.3 a	181.0 a	184.6 b
Radiant	7.0 fl	199.0 a	88.0 cd	125.3 fg	100.8 d	117.3 a	93.3 c	161.5 a	132.8 a	117.0 f-h
Closer SC	2.0 fl	197.8 a	149.3 bc	226.8 a-d	173.3 a-c	159.5 a	138.8 bc	165.3 a	166.3 a	168.4 bc
Closer SC r/w Radiant SC	2.0 fl 7.0 fl	180.8 a	148.8 bc	207.3 b-e	185.8 ab	179.0 a	187.5 b	184.8 a	111.5 a	172.1 b
Closer SC r/w Radiant SC r/w Lannate LV	2.0 fl 7.0 fl 36.0 fl	257.3 a	193.0 ab	281.5 a	173.8 ab	148.8 a	98.8 c	132.8 a	114.8 a	163.3 b-d
Radiant + Grandevo	7.0 fl +16.0 dry	177.8 a	151.8 bc	138.8 e-g	150.5 b-d	135.5 a	122.8 c	152.8 a	134.3 a	140.9 d-f
Closer SC + Grandevo	2.0 fl +16.0 dry	183.5 a	142.5 b-d	196.3 b-e	147.0 b-d	164.3 a	98.0 c	126.8 a	136.0 a	144.4 c-e
Radiant + MBI-206	7.0 fl +128.0 fl	221.0 a	115.8 cd	137.8 e-g	144.8 b-d	144.5 a	144.3 bc	109.8 a	154.0 a	135.8 e-g
Closer SC + MBI-206	2.0 fl +128.0 fl	156.5 a	134.8 b-d	157.8 d-g	136.3 b-d	179.3 a	111.0 c	144.0 a	96.0 a	137.0 e-g
Torac 15EC f/b Radiant f/b Lannate LV	21.0 fl 7.0 fl 36 fl	195.8 a	134.8 b-d	184.0 c-f	171.0 a-c	176.0 a	112.8 c	120.8 a	112.3 a	144.5 c-e
Torac 15EC + LannateLV r/w Radiant	21.0 fl + 36.0 fl 7.0 fl	170.3 a	115.5 cd	105.5 g	96.5 d	150.8 a	93.8 c	75.0 a	154.0 a	113.0 gh
Untreated Check	-----	188.3 a	244.3 a	256.5 ab	218.0 a	221.5 a	250.5 a	202.8 a	210.3 a	229.1 a

Means within columns followed by the same letter are not significantly different LSD; $P = 0.05$

^x PT = pre-treatment. ^y DAA = days after application. ^z PTA = post treatment average.

Table 5. Western Flower Thrips Adults and Larvae per Five Iceberg Lettuce Plants at Holtville, CA 2013.

Treatment	Oz/acre	PT ^x	3DAA ^y 1	7DAA1	11DAA1	8DAA2	3DAA3	7DAA3	10DAA3	PTA ^z
MustangMax f/b Lannate LV	4.0 fl 40.0 fl	574.0 a	307.8 cd	442.3 b-e	361.8 c-f	378.5 cd	262.3 c-e	212.5 c-f	259.3 cd	317.8 d-g
Aza-Direct + M-Pede	24.0 fl+2% v/v	573.0 a	383.8 b-d	403.5 c-e	362.5 c-f	370.8 cd	437.0 b	255.5 c-f	312.8 c	360.8 c-e
Aza-Direct + M-Pede	32.0 fl+1% v/v	591.3 a	418.5 b-d	433.0 b-e	455.5 a-c	540.0 ab	419.0 bc	433.5 ab	535.5 b	462.1 b
Radiant	7.0 fl	530.5 a	279.5 d	350.0 de	274.5 f	214.3 e	160.5 e	229.5 c-f	173.0 d	240.2 h
Closer SC	2.0 fl	556.5 a	389.5 b-d	494.0 a-d	417.8 b-d	415.8 bc	389.8 b-d	313.0 b-d	295.5 cd	387.9 c
Closer SC r/w Radiant SC	2.0 fl 7.0 fl	541.5 a	435.5 bc	537.3 a-c	466.3 a-c	356.8 cd	361.3 b-d	314.0 bc	204.0 cd	382.1 cd
Closer SC r/w Radiant SC r/w Lannate LV	2.0 fl 7.0 fl 36.0 fl	687.8 a	469.0 b	602.3 ab	481.8 ab	373.5 cd	266.3 b-e	241.3 c-f	224.0 cd	379.7 cd
Radiant + Grandevo	7.0 fl+16.0 dry	579.5 a	397.8 b-d	335.5 de	394.0 b-e	265.3 de	268.8 b-e	241.3 c-f	209.5 cd	301.7 e-h
Closer SC + Grandevo	2.0 fl+16.0 dry	515.3 a	356.0 b-d	407.0 c-e	368.3 b-f	350.3 c-e	257.8 c-e	258.5 c-f	295.3 cd	327.6 c-f
Radiant + MBI-206	7.0 fl+128.0 fl	638.0 a	370.5 b-d	384.0 c-e	308.0 d-f	250.5 de	262.0 c-e	174.3 ef	200.8 cd	278.6 f-h
Closer SC + MBI-206	2.0 fl+128.0 fl	523.5 a	368.5 b-d	228.5 de	357.3 c-f	433.5 bc	256.8 c-e	275.0 c-e	198.8 cd	318.3 d-g
Torac 15EC f/b Radiant f/b Lannate LV	21.0 fl 7.0 fl 36 fl	530.3 a	355.8 b-d	450.0 b-e	403.3 b-d	349.0 c-e	220.8 de	191.8 d-f	184.5 cd	307.9 e-g
Torac 15EC+LannateLV r/w Radiant	21.0 fl +36.0 fl 7.0 fl	571.5 a	383.8 b-d	310.0 e	279.3 ef	263.5 de	169.5 de	139.3 f	223.8 cd	252.7 gh
Check	-----	534.8 a	695.3 a	659.5 a	569.0 a	664.0 a	811.0 a	483.8 a	741.5 a	660.6 a

Means within columns followed by the same letter are not significantly different LSD; $P = 0.05$

^x PT = pre-treatment. ^y DAA = days after application. ^z PTA = post treatment average.

Table 6. Numbers of Thrips Damaged, Market, and kg Market Heads per 0.001 acre, and Percentages of Market Heads for Plants in Iceberg Lettuce, 2013.

Treatment	Oz/acre	Total heads	Thrips damage	Market heads	Kg market heads	% Market heads
MustangMax f/b Lannate LV	4.0 fl 40.0 fl	25.8 a	6.3 c-f	19.5 a-d	11.7 a	75.7 a-d
Aza-Direct + M-Pede	24.0 fl + 2% v/v	26.0 a	7.5 b-d	18.5 a-d	9.9 a	70.9 b-d
Aza-Direct + M-Pede	32.0 fl + 1% v/v	25.5 a	5.3 c-f	20.3 a-c	10.0 a	78.9 a-c
Radiant	7.0 fl	24.3 a	2.8 f	21.5 a-c	13.5 a	88.3 a
Closer SC	2.0 fl	27.8 a	9.0 bc	18.8 a-d	10.6 a	67.5 cd
Closer SC r/w Radiant SC	2.0 fl 7.0 fl	26.0 a	4.8 d-f	21.3 a-c	11.0 a	81.4 a-c
Closer SC r/w Radiant SC r/w Lannate LV	2.0 fl 7.0 fl 36.0 fl	24.5 a	6.0 c-f	18.5 a-d	11.7 a	75.2 a-d
Radiant + Grandevo	7.0 fl +16.0 dry	29.0 a	7.0 b-e	22.0 a-c	13.5 a	75.9 a-d
Closer SC + Grandevo	2.0 fl +16.0 dry	27.3 a	10.5 ab	16.8 cd	9.6 a	61.8 de
Radiant + MBI-206	7.0 fl +128.0 fl	28.3 a	4.5 d-f	23.8 a	16.3 a	84.5 ab
Closer SC + MBI-206	2.0 fl +128.0 fl	23.5 a	6.3 c-f	17.3 b-d	11.3 a	73.4 a-d
Torac 15EC f/b Radiant f/b Lannate LV	21.0 fl 7.0 fl 36 fl	25.5 a	3.0 ef	22.5 ab	12.7 a	88.2 a
Torac 15EC + Lannate LV r/w Radiant	21.0 fl + 36.0 fl 7.0 fl	26.5 a	4.8 d-f	21.8 a-c	12.2 a	82.0 a-c
Check	-----	28.3 a	14.0 a	14.3 d	8.5 a	50.7 e

Means within columns followed by the same letter are not significantly different LSD; $P = 0.05$.

Table 7. Western Flower Thrips Larvae per Five Romaine Lettuce Plants at Holtville, CA 2013.

Treatment	Oz/acre	PT ^x	3DAA ^y 1	7DAA1	11DAA1	8DAA2	3DAA3	7DAA3	10DAA3	3DAA4	8DAA4	PTA ^z
Radiant f/b Lannate LV f/b Aza-Direct	8.0 36.0 32.0	1561.3 a	654.3 b	576.8 c	629.0 bc	297.3 c	156.0 e	161.3 bc	168.8 c-e	84.8 de	54.5 d	309.2 ef
Lannate LV r/w Radiant	36.0 7.0	1224.8 a	766.0 b	623.5 bc	518.0 c	287.8 c	213.0 de	83.0 c	66.8 e	44.3 e	21.0 d	291.5 f
Radiant	7.0	1465.0 a	853.8 b	773.8 bc	502.5 c	356.0 c	157.0 e	89.8 c	72.0 e	29.5 e	17.8 d	316.9 ef
Torac 15EC f/b Radiant f/b Lannate LV f/b Torac 15EC	21.0 7.0 36 21.0	1135.8 a	716.3 b	752.8 bc	495.8 c	259.3 c	124.3 e	91.0 c	103.5 de	54.8 de	12.8 d	290.0 f
Torac 15EC + Lannate LV r/w Radiant	21.0 36.0 7.0	1517.3 a	658.0 b	628.5 bc	526.0 c	264.3 c	157.5 e	60.3 c	70.0 e	48.8 de	26.0 d	271.0 f
Gladiator	10.0	1275.3 a	731.8 b	620.0 bc	567.8 c	592.5 b	280.5 c-e	150.8 bc	155.8 c-e	175.5 cd	113.0 cd	376.4 de
Gladiator	14.0	1216.8 a	639.5 b	875.8 ab	608.0 bc	642.3 b	427.3 c	109.3 bc	352.3 bc	249.5 c	235.0 bc	459.9 c
Gladiator	19.0	1347.8 a	656.5 b	821.0 a-c	591.8 bc	705.0 b	382.3 cd	240.8 b	302.8 b-d	263.8 c	104.3 d	452.0 cd
Aza-Direct + M-Pede	32.0 2% v/v	1292.3 a	903.8 ab	813.3 a-c	757.8 b	914.8 a	701.5 b	483.0 a	395.5 b	510.3 b	316.3 b	644.0 b
Radiant r/w Movento r/w Lannate LV	8.0 5.0 36.0	1056.3 a	367.5 b	711.3 bc	489.8 c	386.3 c	276.5 c-e	111.5 bc	92.3 b	117.5 de	32.5 d	317.2 ef
Check	-----	1140.5 a	1167.8 a	1067.8 a	1033.0 a	946.8 a	1089.0 a	494.0 a	752.5 a	709.8 de	682.5 a	882.6 a
LDS, $P = 0.05$		NS	309.6	256.3	189.8	178.0	187.3	143.5	221.6	130.0	123.0	79.1

Means within columns followed by the same letter are not significantly different LSD; $P = 0.05$

^x PT = pre-treatment. ^y DAT = days after treatment. ^z PTA = post treatment average.

Table 8. Western Flower Thrips Adults per Five Romaine Lettuce Plants at Holtville, CA 2013.

Treatment	Oz/acre	PT ^x	3DAA ^y 1	7DAA1	11DAA1	8DAA2	3DAA3	7DAA3	10DAA3	3DAA4	8DAA4	PTA ^z
Radiant f/b Lannate LV f/b Aza-Direct	8.0 36.0 32.0	387.5 a	198.3 a-c	163.8 b-d	181.5 c	140.5 a	97.0 b	127.5 bc	145.8 cd	129.0	213.8 ab	155.2 c
Lannate LV r/w Radiant	36.0 7.0	383.8 a	190.0 bc	127.0 d	142.3 c	111.3 a	119.3 b	86.5 cd	125.8 d	151.8	169.0 b-c	135.9 c
Radiant	7.0	358.8 a	179.8 c	151.8 cd	141.3 c	152.8 a	134.3 b	90.8 cd	126.5 d	121.5	186.8 a-c	142.8 c
Torac 15EC f/b Radiant f/b Lannate LV f/b Torac 15EC	21.0 7.0 36 21.0	234.5 a	165.5 c	168.5 b-d	188.3 bc	105.0 a	84.3 b	47.8 d	141.0 d	137.0	141.5 b-d	131.0 c
Torac 15EC + Lannate LV r/w Radiant	21.0 36.0 7.0	354.0 a	138.5 c	138.3 d	172.3 c	210.0 a	147.0 b	107.8 cd	172.8 b-d	137.8	191.3 a-c	157.3 c
Gladiator	10.0	232.3 a	168.5 c	172.8 b-d	183.5 c	129.3 a	98.3 b	89.3 cd	164.8 cd	153.3	98.8 d	139.8 c
Gladiator	14.0	355.0 a	154.8 c	226.3 ab	207.0 bc	166.3 a	112.5 b	69.0 cd	274.8 ab	141.3	153.5 b-d	167.3 c
Gladiator	19.0	365.0 a	164.8 c	156.0 b-d	118.3 c	164.3 a	84.8 b	89.8 cd	193.3 b-c	186.3	115.3 cd	141.4 c
Aza-Direct + M-Pede	32.0 2% v/v	329.0 a	271.5 a	219.8 a-c	280.3 b	297.5 a	129.0 b	194.3 ab	250.0 bc	201.0	171.3 a-d	223.8 b
Radiant r/w Movento r/w Lannate LV	8.0 5.0 36.0	258.5 a	189.3 bc	189.5 b-d	176.0 c	162.3 a	95.8 b	78.5 cd	147.3 cd	163.5	138.5 b-d	148.9 c
Check	-----	265.5 a	262.0 ab	265.8 a	383.8 a	242.8 a	284.8 a	197.5 a	363.5 a	268.3	257.3 a	280.6 a
LDS, P= 0.05		NS	74.2	73.6	92.4	NS		69.4	106.4	NS	86.7	46.4

Means within columns followed by the same letter are not significantly different LSD; $P = 0.05$

^x PT = pre-treatment. ^y DAT = days after treatment. ^z PTA = post treatment average.

Table 9. Western Flower Thrips Adults and Larvae per Five Romaine Lettuce Plants at Holtville, CA 2013.

Treatment	Oz/acre	PT ^x	3DAA ^y 1	7DAA1	11DAA1	8DAA2	3DAA3	7DAA3	10DAA3	3DAA4	8DAA4	PTA ^z
Radiant f/b Lannate LV f/b Aza-Direct	8.0 36.0 32.0	1947.8 a	827.5 c	740.5 c	835.5 b	437.8 d	253.0 c	288.8 bc	314.5 cd	213.8 de	268.3 cd	464.4 ef
Lannate LV r/w Radiant	36.0 7.0	1633.5 a	956.0 bc	750.5 c	685.3 b	374.0 d	329.8 c	149.5 bc	192.5 d	196.0 e	190.0 d	424.8 f
Radiant	7.0	1823.8 a	1033.5 bc	928.0 bc	643.8 b	506.3 cd	291.3 c	183.0 bc	223.5 d	151.0 e	204.5 d	462.8 ef
Torac 15EC f/b Radiant f/b Lannate LV f/b Torac 15EC	21.0 7.0 36 21.0	1370.3 a	931.8 bc	921.0 bc	684.0 b	364.3 d	208.5 c	136.3 c	244.5 d	191.8 e	154.3 d	426.3 f
Torac 15EC + Lannate LV r/w Radiant	21.0 36.0 7.0	1871.3 a	796.5 c	766.5 c	698.3 b	399.3 d	304.5 c	168.0 bc	242.8 d	186.5 e	219.5 cd	420.2 f
Gladiator	10.0	1507.5 a	900.3 bc	792.8 bc	726.3 b	721.8 bc	378.8 c	214.0 bc	320.5 cd	328.8 c-e	211.8 d	510.5 de
Gladiator	14.0	1571.8 a	791.8 c	1101.3 ab	890.0 b	808.5 b	539.8 bc	178.3 bc	627.0 bc	415.8 cd	363.5 bc	635.1 c
Gladiator	19.0	1712.8 a	821.0 c	977.0 bc	710.0 b	844.3 b	467.8 bc	330.5 b	496.0 b-d	450.0 c	219.5 cd	590.6 cd
Aza-Direct + M-Pede	32.0 2% v/v	1621.3 a	1150.3 b	1033.0 a-c	813.0 b	1187.3 a	830.5 ab	652.3 a	645.5 b	736.3 b	485.0 b	837.0 b
Radiant r/w Movento r/w Lannate LV	8.0 5.0 36.0	1309.8 a	826.5 c	900.8 bc	665.8 b	546.0 cd	372.3 c	190.3 bc	239.5 d	281.0 c-e	171.0 d	465.9 ef
Check	-----	1403.5 a	1554.7 a	1333.5 a	1416.8 a	1189.3 a	1110.3 a	641.3 a	1116.0 a	978.0 a	939.8 a	1142.2 a
LDS, $P = 0.05$		NS	319.4	310.2	291.7	244.5	389.7	182.0	313.1	208.7	151.4	83.3

Means within columns followed by the same letter are not significantly different LSD; $P = 0.05$

^x PT = pre-treatment. ^y DAT = days after treatment. ^z PTA = post treatment average.

Table 10. Numbers of Thrips Damaged, Market, and kg Market Romaine Hearts per 0.001 acre, and Percentages of Market Heads for Plants in Romaine Lettuce, 2013.

Treatment	Oz/acre	Total hearts	Thrips damage	Market hearts	Kg market hearts	% Market hearts
Radiant f/b Lannate LV f/b Aza-Direct	8.0 36.0 32.0	29.50 a	5.0 c	24.50 ab	14.33 a	82.94 ab
Lannate LV r/w Radiant	36.0 7.0	31.50 a	8.75 b	22.75 ab	13.00 ab	72.32 bc
Radiant	7.0	32.00 a	5.75 bc	26.25 a	12.59 a-c	80.25 a-c
Torac 15EC f/b Radiant f/b Lannate LV f/b Torac 15EC	21.0 7.0 36 21.0	26.00 a	6.50 bc	19.50 bc	13.04 ab	75.02 a-c
Torac 15EC + Lannate LV r/w Radiant	21.0 36.0 7.0	30.00 a	4.75 c	25.25 a	14.08 a	84.46 a
Gladiator	10.0	27.75 a	8.00 bc	19.75 bc	11.70 bc	71.05 c
Gladiator	14.0	26.75 a	5.00 c	21.75 a-c	12.31 a-c	81.51 a-c
Gladiator	19.0	26.75 a	7.00 bc	19.75 bc	11.35 bc	73.81 a-c
Aza-Direct + M-Pede	32.0 2% v/v	30.25 a	8.50 b	21.75 a-c	10.63 cd	72.54 bc

Radiant r/w	8.0	28.00 a	5.50 bc	22.50 ab	13.33 ab	80.23 a-c
Movento r/w	5.0					
Lannate LV	36.0					
Check	-----	29.50 a	12.50 a	17.00 c	8.54 d	57.69 d
LDS, $P= 0.05$		NS	3.46	5.32	2.17	11.69

Means within columns followed by the same letter are not significantly different LSD; $P = 0.05$.