Knockdown and Residual Efficacy of Biopesticides and Reduced-Risk Insecticides against Western Flower Thrips in Romaine Lettuce

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Abstract

Three separate field trials over two years were conducted to evaluate the comparative knockdown and residual efficacy of several conventional, Reduced-risk and biopesticide compounds against western flower thrips in romaine lettuce. These trials consistently demonstrated that both Lannate-pyrethroid combinations and Success provided significant knockdown and residual control of thrips adults and larvae when compared to the other spray biopesticide treatments. Unfortunately, the biopesticide alternatives at best provided poor to marginal efficacy against western flower thrips. The implication of these results on desert lettuce production and resistance management programs is discussed.

Introduction

Western flower thrips, *Frankiniella occidentalis*, have rapidly become an important pest in desert head lettuce production. They primarily occur in large numbers on lettuce during the fall and spring and can build up to high numbers very rapidly. Under mild-winter temperatures, thrips reproduce quickly on lettuce. Adults can migrate onto lettuce crops in large numbers during the spring when weeds dry down or when crops are harvested. They are presently one of the most economically important insect pests of lettuce because of their damage potential and lack of viable management alternatives. As these small insects feed, they damage lettuce by scarring edible leaves, cause rib discoloration and contaminate marketable plant portions at harvest. Romaine, leaf lettuces and spinach are especially susceptible to thrips feeding and growers have a very low tolerance for damage and contamination. Thrips are very difficult to control because adults are quite agile and larvae inhabit plant parts that are difficult to reach with sprays, and they can rapidly develop resistance to insecticides.

Pest management programs for thrips on lettuce crops in Arizona have been developed around the availability of effective insecticides. With the exception of the recent registration of Success, thrips control has been achieved almost entirely through the use of organophosphate and carbamate insecticides. These compounds provide good control of thrips larvae on lettuce, but only marginal control against adults. Thus, growers typically tank-mix them with a pyrethroid to control both lifestages. Loss of Ops and carbamates would not only make thrips control very difficult and expensive, but would place an enormous amount of selective pressure on Success and pyrethroids. Because of these threats, and the need for control measures for thrips in organic lettuce production, it has become clear that additional chemical compounds that can effectively control thrips would greatly benefit the industry. Therefore, studies were initiated to evaluate the efficacy of several Reduced-risk, botanical and biological insecticides against western flower thrips on spring romaine lettuce under desert growing conditions.

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Materials and Methods

Fall 2000. Romaine lettuce 'PIK 417' was direct seeded on 1 Oct at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Plots were two beds wide by 50 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a randomized complete block design. Formulations and rates for each compound are provided in the Table 1. Foliar applications were made with a CO_2 operated boom sprayer operated at 50 psi and 26.5 GPA. A directed spray (~75% band, with rate adjusted for band) was delivered through 3 nozzles (TX-18) per bed. Sprays were applied on 15 and 29 Nov, and 11 and 27 Dec. Numbers of thrips (adults and larvae combined) from 5-8 plants per replicate were recorded on each sample date. Relative thrips numbers were measured by removing plants and beating them vigorously against a screened pan for a predetermined time. A 6 in. by 6 in. sticky trap was placed inside of the pan to catch the dislodged thrips. Sticky traps were then taken to the laboratory where adult and larvae were counted. WFT counts were transformed ($\log_{10}$ n+1) before analysis of variance to stabilize variances that were found to be heterogeneous. Untransformed means are presented in tables. Data were analyzed as a 1-way ANOVA with means compared where appropriate using a protected LSD *F* test $_{(p<0.05)}$.

Spring 2001. Romaine lettuce 'PIK 417' was direct seeded on 10 Jan at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Plots were two beds wide by 50 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a randomized complete block design. Formulations and rates for each compound are provided in the Table 2. Foliar applications were made with a CO_2 operated boom sprayer operated at 50 psi and 26.5 GPA. A directed spray (~75% band, with rate adjusted for band) was delivered through 3 nozzles (TX-18) per bed. Sprays were applied on 14, 21, 29 Mar, and 5, 16 Apr. Comate crop oil at 1.0% and a spray buffer, BuffIT (2 oz/acre), was added to AZA-Direct and Agroneem to lower spray pH to @5.5. An adjuvant (Kinetic at 0.065% v/v) was added to the Avaunt, Success and Actara treatments. Comate crop oil (0.5% v/v) was added to all other treatments, except Sulpreme 52 sulfur and Naturalis L. Numbers of thrips (adults and larvae combined) from 5-8 plants per replicate were recorded on each sample date. Relative thrips numbers were measured by removing plants and beating them vigorously against a screened pan for a predetermined time. A 6 in by 6 in sticky trap was placed inside of the pan to catch the dislodged thrips. Sticky traps were then taken to the laboratory where adult and larvae were counted. WFT counts were transformed ($\log_{10}$ n+1) before analysis of variance to stabilize variances that were found to be heterogeneous. Untransformed means are presented in tables. Data were analyzed as a 1-way ANOVA with means compared where appropriate using a protected LSD *F* test $_{(p<0.05)}$.

Fall 2001. Romaine lettuce 'PIK 417' was direct seeded on 2 Oct at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Plots were two beds wide by 50 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a randomized complete block design. Formulations and rates for each compound are provided in the Table 3. Foliar applications were made with a CO_2 operated boom sprayer operated at 50 psi and 25 GPA. A directed spray (~75% band, with rate adjusted for band) was delivered through 3 nozzles (TX-18) per bed. Sprays were applied on 14 and 24 Nov, and 1 Dec. Comate crop oil at 1.0% and a spray buffer, BuffIT (2 oz/acre), was added to AZA-Direct to lower spray pH to @5.5. An adjuvant (DyneAmic) at 0.065% v/v was added to the Lannate+Mustang, Success and Actara treatments. All other treatments were applied as noted in Table 3. Numbers of thrips (adults and larvae combined) from 5-8 plants per replicate were recorded on each sample date. Relative thrips numbers were measured by removing plants and beating them vigorously against a screened pan for a predetermined time. A 6 in by 6 in sticky trap was placed inside of the pan to catch the dislodged thrips. Sticky traps were then taken to the laboratory where adult and larvae were counted. WFT counts were transformed ($\log_{10}$ n+1) before analysis of variance to stabilize variances that were found to be heterogeneous. Untransformed means are presented in tables. Data were analyzed as a 1-way ANOVA with means compared where appropriate using a protected LSD *F* test $_{(p<0.05)}$.

Results and Discussion

Fall 2000. WFT populations were moderate to heavy during this trial. Lannate+Warrior and Success were the only treatments that consistently provided significant reductions in WFT compared with the untreated check (Table 1). On several sample dates following the 2nd application, Actara significantly reduced WFT numbers. Among the biopesticides, plants treated with Neemix and AZA-Direct contained significantly fewer WFT than the check on several sample dates following the 3rd and 4th applications. None of the other biopesticide products significantly reduced WFT numbers compared with the check. When WFT control was averaged over the season, only the Lannate+Warrior and Success treatments provided economic control of adults and larvae (Figure 1). Lannate and Warrior provided similar control of both lifestages, while Success appeared to be more active on larvae. Actara provided about 35% control, and the remaining biopesticide treatments did not provide adequate control. Only AZA-Direct provided larval control greater than 15%.

Spring 2001. WFT populations were heavy during the spring trial consisting primarily of adults. Movement of adults in and out of plots from outside crops was heavy and tended to influence our adult sample counts. The Lannate+Avaunt and Success treatments provided the most significant control of WFT following each application, but appeared to be less efficacious in April due to the heavy migration of adults into all plots (Table 2). Similar to the previous study, Actara provided inconsistent efficacy, particularly following the last two applications. With the exception of the Comate and Naturalis treatments following the 1st application, none of the biopesticide treatments provided efficacy of WFT relative to the untreated check (Table 2). No differences in WFT numbers were observed among treatments and the untreated check on the final sample date when adult dispersal was very heavy within the experimental area. Larval control appeared to be significantly greater than adult control in the Success plots (Fig 2), but may also reflect the high level of dispersal that occurs during the spring. Avaunt appears to provide only marginal thrips control, as it was only effective when combined with Lannate. Similar to the fall trial, the biopesticides did not provide significant economic control of WFT under these conditions.

Fall 2001. WFT populations were relatively light in this trial compared to the previous tests. Surprisingly, all treatments, except the Garlic and Comate oil, provided significant reduction of WFT compared to the check at 2 days following the first application (Table 3). The only treatment to prevent any WFT increase at that time was Lannate+Mustang. However, the only compounds that showed any residual efficacy at 6 days following the first application were Lannate+Mustang, Success and Actara. Following the 2nd application again several biopesticide treatments provided significant knockdown (3 DAT) efficacy including AZA-Direct, Naturalis, Safer Soap and Garlic. Again residual efficacy was not observed for these treatments. Following the 3rd application, Orosorb (limonene) provided significant knockdown and residual efficacy. However, none of the biopesticide during the trial provided efficacy that was statistically comparable to either Lannate+Mustang or Success (Table 3). This is further evident in Fig 3 which illustrates the level of WFT control averaged over the season for each treatment.

In conclusion, these studies demonstrate that Lannate combinations and Success are the most efficacious WFT compounds available to growers. Table 4 provides a summary of the average % knockdown (2-3 days following application) and residual (6-8 days following sprays) control provided for each products averaged across all applications and trials. Lannate used in combination with Warrior or Mustang provided > 80 % control for both adult and larvae under the varied conditions during these trials. Success, provided similar knockdown and residual control of larvae, but had less residual control of adults. The fact that Success is considered a Reduced-risk product is a benefit to growers and the compound provides a viable option to rotate with Lannate and pyrethroids for resistance management purposes. Although Actara provided ~40% control of WFT, it has shown in other studies to be even more efficacious when used with pyrethroids. Unfortunately, Actara is a neonicotinoid and would not be a logical rotational partner in the desert where growers rely heavily on Admire. Finally, the lack of efficacy and WFT control found in the biopesticides (Table 4) suggests that thrips management in romaine lettuce would be very difficult in the absence of either Lannate or Success. This is presently a concern because of the potential for losing Lannate due to reregistration under FQPA, and because of the already heavy reliance on Success for worm, leafminer and thrips management in the desert southwest.

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Table 1.

Treatment/ formulation	Rate or conc. / acre	Mean no. WFT / plant										
		Nov 9	**Nov 18**	**Nov 22**	**Nov 27**	**Dec 2**	**Dec 5**	**Dec 9**	**Dec 13**	**Dec 19**	**Dec 27**	**Jan 8**
Lannate 90S + Warrior T	0.75 lb +3.8 oz	10.5 a	2.7 d	8.2 e	25.0 e	13.9d	13.7 b	6.5 e	3.4 f	0.7 f	3.2 f	1.6 f
Success 2F	6.0 oz	11.2 a	4.7 cd	12.9 de	39.7 d	15.4 d	17.5 b	8.5 e	5.7 e	2.3 e	5.2 e	3.8 e
Actara 25W	4.5 oz	5.6 a	8.1 abc	22.3 bc	60.1 c	36.5 c	43.3 a	22.6 d	19.9 d	11.9 d	13.1 d	12.4 d
Neemix 4.5	16 oz	7.8 a	12.7 ab	31.5 ab	109.2 a	54.7 b	48.3 a	43.7 abc	39.0 c	15.3 cd	16.0 cd	16.1 cd
Ecozin 3%EC	10 oz	11.0 a	9.8 ab	30.4 ab	83.5 ab	51.3 bc	53.3 a	45.0 abc	42.6 bc	28.1 ab	25.7 ab	18.3 bcd
Agroneem EC	48 oz	10.6 a	9.0 ab	23.1 bc	77.7 abc	56.4 ab	59.3 a	45.9 abc	51.0 ab	30.0 ab	30.1 a	25.8 abc
AZA-Direct EC	24 oz	5.5 a	8.1 abc	24.7 abc	69.1 bc	57.9 ab	50.9 a	40.7 abc	41.7 bc	19.2 bcd	17.3 bcd	18.2 bcd
Trilogy	1 %	5.8 a	11.1 ab	18.4 cd	64.0 bc	58.3 ab	58.3 a	41.1 abc	46.7 bc	28.9 ab	28.1 a	24.1 abc
Comate 101	1 %	6.0 a	10.6 ab	26.4 abc	66.1 bc	51.4 b	61.0 a	36.8 bc	58.0 ab	25.1 ab	27.8 a	32.5 a
Garlic Barrier	10%	9.0 a	8.3 abc	30.4 ab	77.7 abc	55.5 ab	59.5 a	38.2 abc	48.9 ab	22.7 abc	28.9 a	24.3 abc
Hot Pepper Wax	6 %	9.3 a	10.5 ab	24.9 abc	67.3 bc	64.7 ab	56.0 a	38.7 abc	46.3 bc	30.5 ab	30.3 a	22.3 abc
Sul-Preme 5	5 pts	11.2 a	13.5 a	23.3 bc	68.4 bc	51.6 bc	54.1 a	33.3 c	46.5 ab	24.4 abc	28.3 a	25.3 abc
Orange Guard	50%	5.5 a	12.1 ab	35.9 a	75.6 bc	74.9 a	53.2 a	53.1 a	55.3 ab	31.6 ab	27.4 a	29.6 ab
SaferSoap+Trilogy	2% + 1%	10.5 a	9.9 ab	24.6 abc	71.9 bc	62.6 ab	56.9 a	48.7 ab	51.1 ab	31.9 a	24.4 abc	19.3 abc
Untreated		9.5 a	7.7 bc	32.4 ab	80.2 abc	54.1 ab	50.4 a	49.3 ab	66.0 a	28.9 ab	31.8 a	30.2 ab

Means followed the same letter are not significantly different ; ANOVA, protected LSD $(p < 0.05)$

Table 2.

Treatment/ formulation	Rate or conc. (v/v) per acre	Mean no. WFT / plant				
		Mar 19	**Mar 27**	**Apr 4**	**Apr 11**	**Apr 19**
Lannate 90S + Avaunt WDG	0.75 lb +3.5 oz	163.9 b	30.7 f	42.4 de	24.0 e	26.0 e
Asana XL + Avaunt WDG	9.6 oz+ 3.5 oz	210.0 ab	99.2 d	78.4 bc	40.8 cd	67.3 ab
Success 2F	6.0 oz	109.21 c	40.4 ef	26.0 e	28.8 de	26.7 de
Actara 25W	4.5 oz	192.3 ab	52.8 e	57.6 cd	58.4 abc	78.7 a
AZA-Direct EC	24 oz	212.0 ab	105.2 bcd	57.7 cd	48.0 bc	56.0 abc
Agroneem	48 oz	229.2 a	159.6 ab	78.4 bc	45.6 bcd	46.7 abcd
Comate 101	2 %	163.5 b	170.4 a	249.3 a	65.2 ab	45.3 bcde
Garlic Barrier	8 %	216.4 ab	147.2 abc	116.8 b	55.6 abc	44.0 abcde
Sul-Preme 5	5 pts	245.6 a	169.2 a	116.9 ab	82.4 a	72.0 ab
Pyrellin EC	32 oz	251.2 a	141.6 abcd	95.0 bc	70.0 ab	54.0 abc
Safer Soap	3 %	251.2 a	104.0 cd	80.4 bc	51.2 bc	38.4 cde
Naturalis L	16 oz	162.8 b	185.2 a	92.0 bc	64.0 ab	41.3 cde
Untreated	--	253.2 a	146.8 abc	92.4 bc	62.0 ab	50.3 abc

Means followed the same letter are not significantly different ; ANOVA, protected LSD $(p < 0.05)$

Table 3.

Treatment/ formulation	Rate or conc. (v/v) per acre	Mean no. WFT / plant							
		Nov 8	Nov 16	Nov 20	Nov 27	Nov 30	Dec 4	Dec 7	Dec 10
Lannate+Mustang	0.8 lb +4.3 oz	7.7 a	7.6 f	4.1 d	2.8 d	2.9 d	1.2 d	1.8 e	1.5 d
Success	6.0 oz	7.3 a	12.1 ef	10.6 cd	5.0 d	5.4 cd	2.9 cd	3.8 e	3.4 d
Actara	4.0 oz	6.9 a	14.0 def	9.0 d	8.7 cd	10.5 bc	8.3 c	6.6 de	8.5 c
AZA-Direct	32 oz	7.8 a	16.9 cde	23.1 ab	16.2 bc	17.3 a	17.4 b	19.9 abc	15.1 ab
Naturalis L	16 oz	6.4 a	16.9 cde	23.9 ab	16.5 bc	15.9 ab	16.9 b	16.7 bc	15.5 ab
Hot Pepper Wax	6%	9.0 a	18.3 cde	20.7 ab	22.8 ab	17.9 a	16.4 b	20.4 ab	15.8ab
Orosorb	1%	7.1 a	20.7 bcd	18.5 b	17.1 abc	18.3 a	18.7 b	12.9 cd	13.4 bc
Pyrellin	2 pts	6.1 a	22.7 bcd	22.4 ab	18.1 ab	16.4 ab	19.7 ab	18.9 bc	16.3 ab
SaferSoap	2 %	9.1 a	21.3 bcd	19.4 b	16.1 bc	20.4 a	19.9 ab	16.9 bc	15.6 ab
Garlic Barrier	10%	5.9 a	22.6 abc	22.9 ab	15.7 bc	20.7 a	18.3 b	21.6 ab	18.2 ab
Comate 101	1 %	8.3 a	27.1 ab	27.4 a	19.9 ab	19.5 a	22.2 ab	23.5 ab	18.2 ab
Sul-Preme 5	4 pts	7.7 a	21.2 bcd	20.0 ab	17.3 ab	21.8 a	21.7 ab	19.5 abc	19.7 a
SaferSoap+Pyrellin+Garlic	2%+ 2 pts+5%	8.6 a	22.3 bcd	20.1 ab	17.3 ab	18.7 a	21.5 ab	19.3 bc	15.5 ab
Untreated		7.5 a	30.9 a	18.0 bc	25.2 a	22.3 a	25.8 a	26.7 a	18.7 a

Means followed the same letter are not significantly different ; ANOVA, protected LSD $(p < 0.05)$

Table 4

	% Control					
	Knockdown (2-3 DAT)			Residual (6-8 DAT)		
Treatment	**n**	**Adults**	**Larvae**	**n**	**Adults**	**Larvae**
Lannate + pyrethroid	7	83.1	80.1	7	84.6	82.6
Success	7	64.6	70.3	11	53.0	71.8
Actara	7	37.6	45.6	11	34.6	43.7
Neemix	4	12.0	22.5	4	23.0	23.3
Ecozin	4	7.3	16.8	4	9.3	9.5
Agroneem	4	1.5	6.5	8	16.3	10.3
AZA-Direct EC	7	13.5	23.6	11	11.4	22.1
Trilogy	4	0	13.8	4	21.3	9.5
Comate 101	7	0	6.9	11	6.5	5.5
Garlic Barrier	7	5.4	17.0	11	8.0	6.9
Hot Pepper Wax	7	8.7	16.0	7	13.4	10.3
Sulfur	7	3.1	13.7	11	10.1	6.4
d- limonene	7	7.4	13.1	7	14.6	9.4
Pyrellin EC	3	5.7	19.0	7	4.7	8.1
Naturalis L	3	20.3	35.0	7	2.0	15.9
SaferSoap	3	17.0	22.6	7	11.4	15.1
SaferSoap+Trilogy	4	9.0	10.0	4	23.0	11.5
SaferSoap+Pyrellin+GarlicBarrier	3	12.3	13.3	3	7.0	14.3
Lannate 90S + Avaunt WDG	-	-	-	4	33.0	61.8
Asana XL + Avaunt WDG	-	-	-	4	10.0	24.8

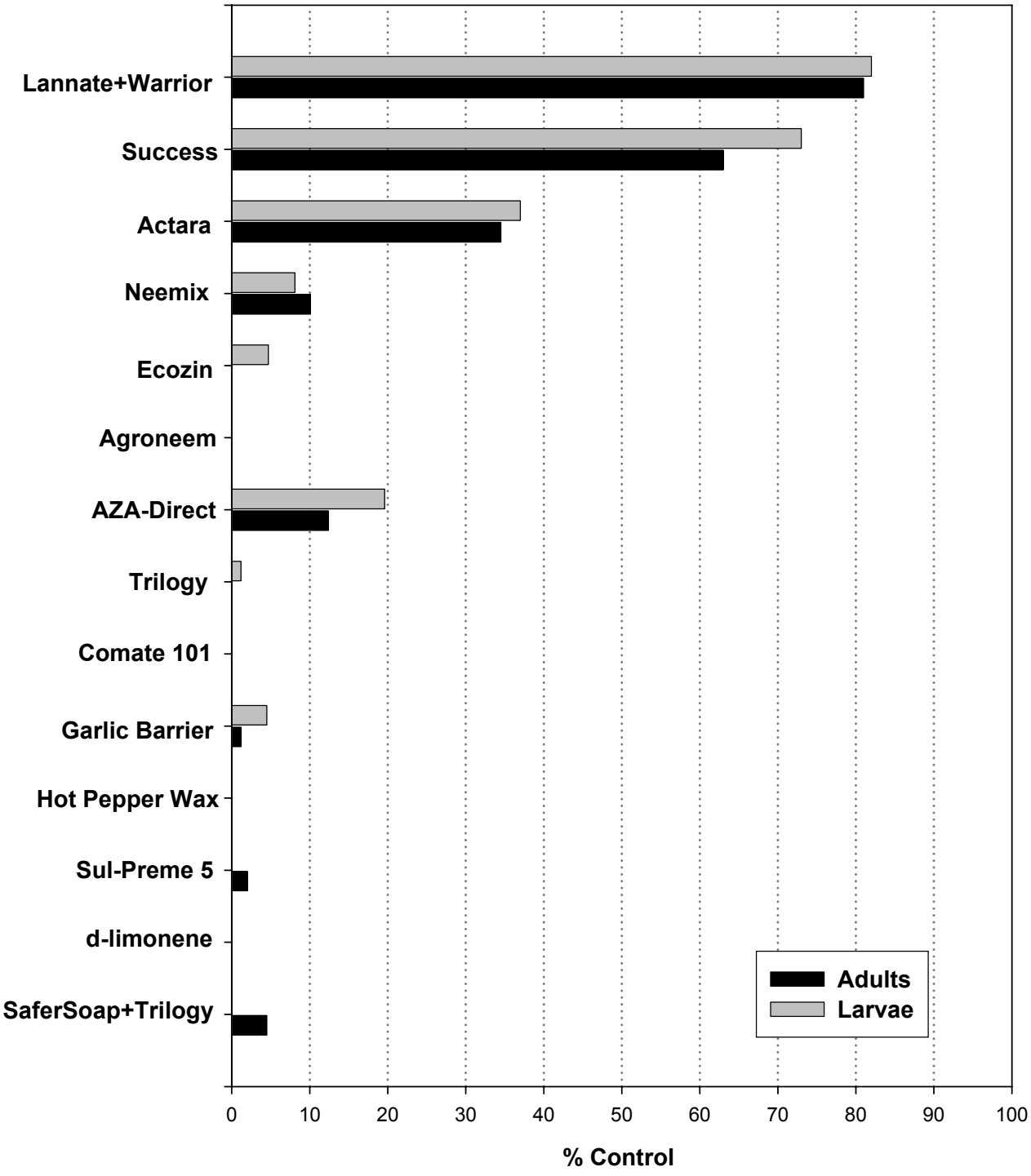

Figure 1. Seasonal average control (%) of western flower thrips on romaine lettuce, Fall 2000.

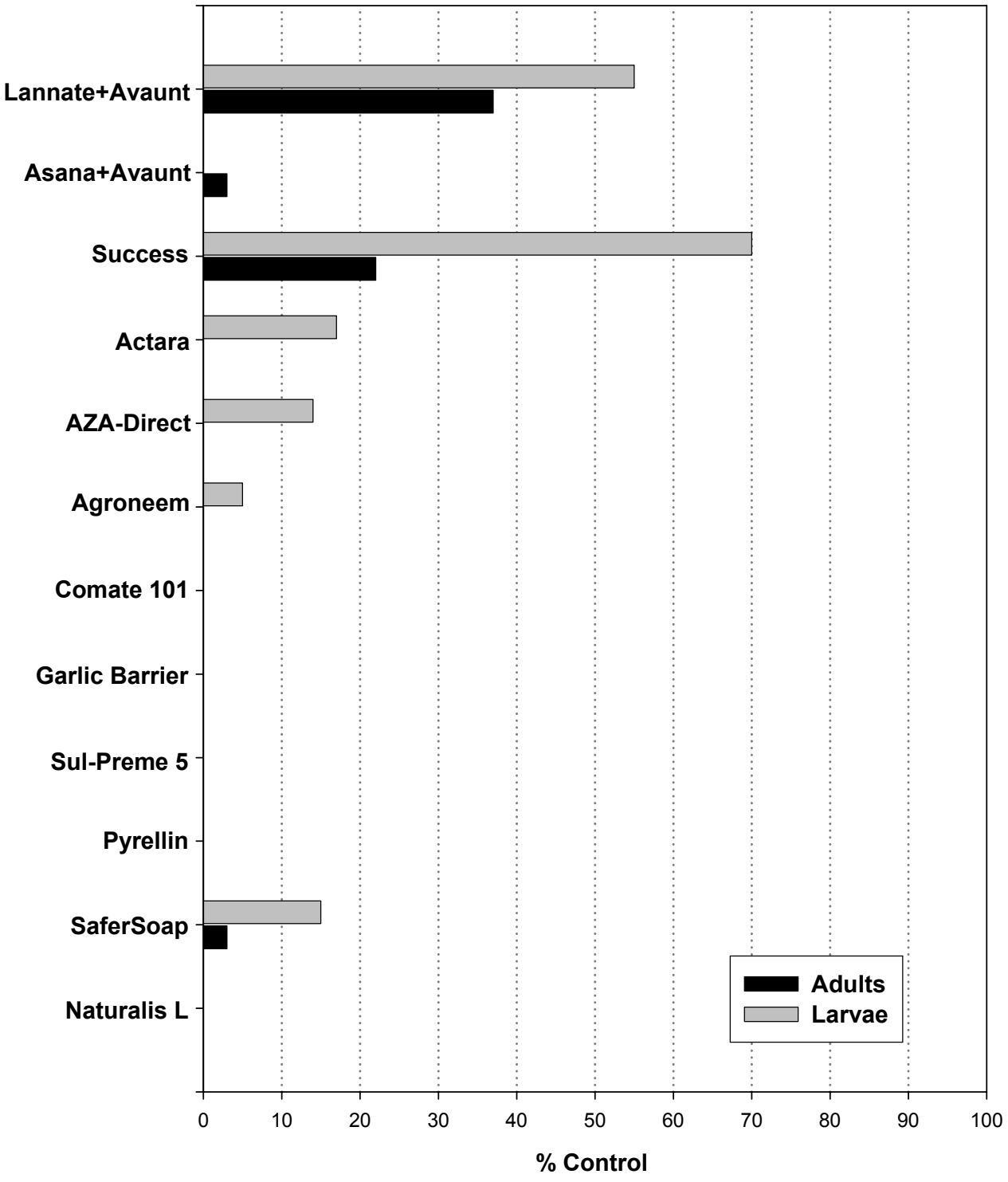

Figure 2. **Seasonal average control (%) of western flower thrips on romaine lettuce, Spring 2001.**

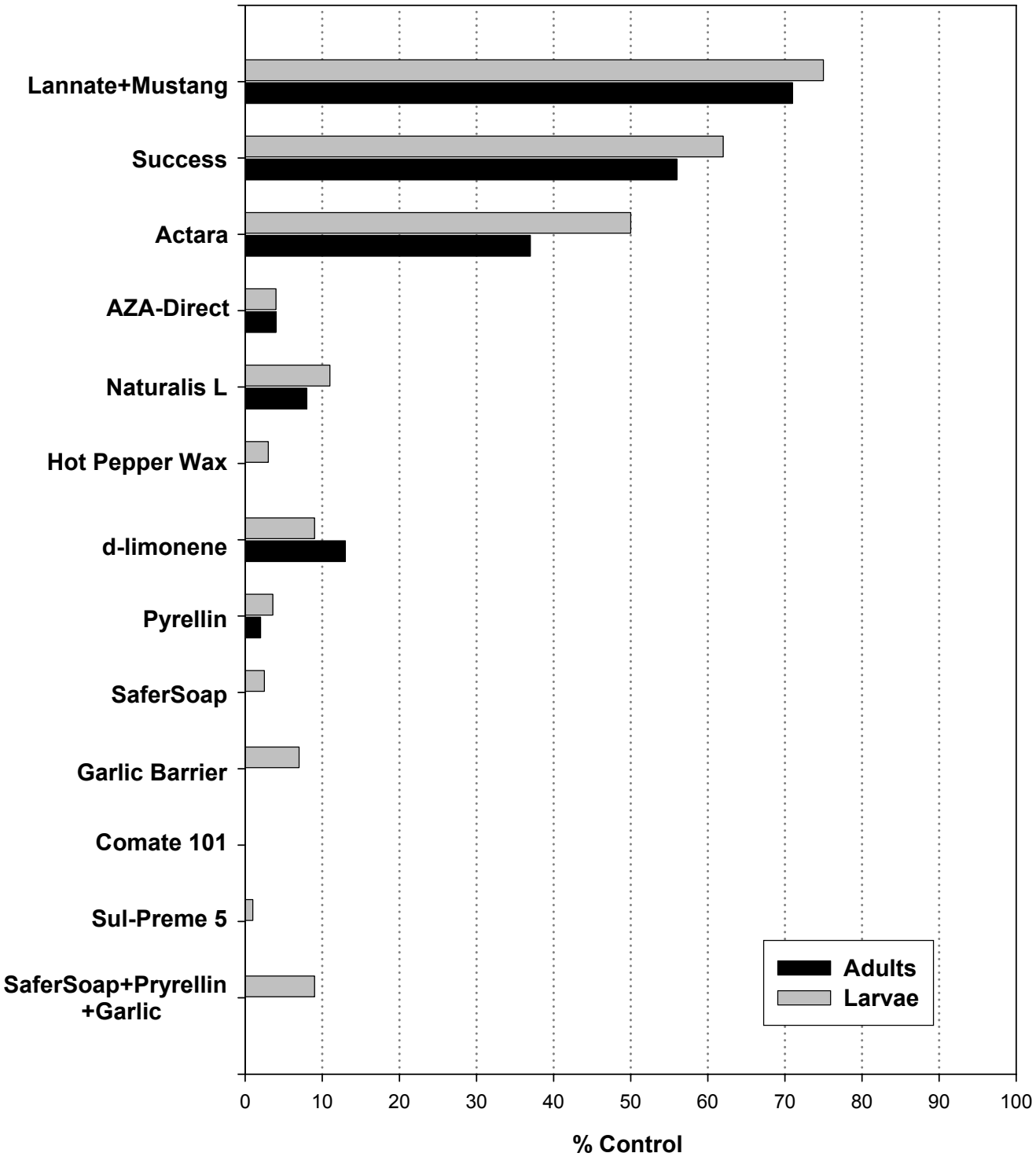

Figure 3. Seasonal average control (%) of western flower thrips on romaine lettuce, Fall 2001.