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MANAGEMENT OF ANTS IN ALMONDS, CITRUS AND TABLE GRAPES

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ABSTRACT

Work was done with the Argentine ant, the native gray ant, and the southern fire ant to determine how to best formulate baits for maximum acceptance by the workers. The research was done in almonds, citrus, and table grapes. The results from each of these commodities can be pooled together, because ant-control problems are similar in each commodity.

Southern fire ants responded best to baits having an animal-lipid base. Some baits having a plant-lipid base, such as soybean oil mixed in corngrit, are less effective for this species. For this reason, Tahara, a bait formulated with hydramethylnon on freeze-dried silkworm pupae, was more effective in controlling southern fire ants than was Amdro, a bait formulated with the same toxicant on soybean oil mixed in corngrit. Similarly, the lack of high effectiveness of the IGR, Logic, in controlling southern fire ants, may be more a function of the lack of acceptability of the attractive component of the bait than the effectiveness of the IGR active component. No materials controlled southern fire ants for more than about 30 days. Future work will be directed toward finding ways to destroy whole colonies, including the reproductive stages, of this and the other species of ants.

Argentine ants responded best to baits having a plant-lipid base or to high-sugar-containing liquid baits. Work is underway to find the most acceptable mixtures of boric acid in sucrose solutions, as well as other sugar-solution-toxicant mixtures for control of this species.

Native gray ants had a particular affinity for anchovy-based baits. The significance of this relationship will be studied further.

OBJECTIVES

1. For each ant species, on each crop of interest, and in each different climatic or geographic area where the ants present a problem on those crops, develop and evaluate a wide variety of formulations of each potential toxicant, to determine chemical, moisture, consistency, granule size, and other characteristics that maximize their acceptability.

2. For each ant species, on each crop of interest, and in each different climatic or geographic area where the ants present a problem on those crops, establish replicated plots of candidate ant-control chemicals, using the most effective baiting procedures found in Objective 1; determine the critical amounts and timings of application that are needed for most effective control.

3. With regard to citrus and table grapes, determine the correlation between ant control using various new chemicals and older standards (lorsban), and infestation of the commodity with pest Homoptera (mealy bugs, scale, aphids, whitefly).

4. Develop repellents for use as bands around the bases of citrus trees or grape vines to exclude ants from these commodities.

5. Establish relations between irrigation strategies, cover crops, and ant infestations, and manipulate irrigation strategies to lessen ant infestations.

6. Determine requirements of federal and state regulatory agencies with regard to registration of the experimental ant control chemicals and establish a practical plan for obtaining this registration.

INTRODUCTION

Ants are often critically important pests in almonds, table grapes, and citrus. In almonds, unlike the other two commodity, the problem is especially severe, because the damage resulting from feeding of southern fire ants has a direct effect upon the market quality of the nuts. Also, southern fire ants frequently crawl inside drip lines and mini-sprinklers, clogging them. Finally, southern fire ants may create a nuisance due to their stinging of workers in heavily infested fields.

Recognizing a need to engage in a concerted research effort to develop ant control on behalf of California agricultural commodity groups, we have assembled a task-force of experts in this area from two campuses of the University of California and from a number of Centers of University of California Cooperative Extension. These individuals have separately worked for a large number of scientist-years on ant species identification, ant life history and habits, bait station design and testing, water management as it affects ant survival, rearing of ants of a variety of species, development and testing of tree-banding repellents, understanding the relations between ants and the pest Homoptera they tend, and insecticidal control of ants in the field.

There are advances in ant control technology that have not received adequate research attention, and we feel that an opportunity to develop highly effective ant control procedures through a concerted, goal-directed research effort is present. Thus, we are approaching the ant-control problem on a multi-commodity basis, giving special emphasis to a research area that has been neglected in recent years - the development of baiting technology that will selectively, rapidly, and effectively control ant pests.

This research does not involve screening a wide variety of new chemicals for ant control potential. Rather, we recognize that there are already available several very effective chemicals that are labeled for ant control under some conditions. A major problem in making these chemicals work for highly effective ant control is related to

acceptance. We must learn how to present the materials to the ants in such a way that they preferentially take them to their colonies, where they may cause death of workers and /or immature ants, or a cessation of production of offspring by the queens. Ant-control materials presently available, on which we are concentrating much of our research, are:
1. Hydramethylnon, formulated on freeze-dried silkworm pupae - "Tahara"
2. Hydramethylnon in soybean oil base - "Amdro"
3. The IGR, phenoxycarb - "Logic"
4. Sulfluoramid, a metabolic inhibitor, as is hydromethylnon
5. Beauveria - (Here we are interacting with scientists from Florida and Colorado, who are already exploring the potential for ant control using this pathogen
6. Boric acid, which is highly toxic to ants and has to be carefully formulated so that it is readily accepted by them and transported to their nests.

Experiments have been conducted across the commodities that support this research, and results are reported for all commodities, because the strategies to be developed for control of ants are largely independent of commodity.

PROCEDURES

Tests for ant preferences for solid blank baits. Various blank ant baits (baits containing the attractive principal only, without toxicant) were formulated in the laboratory of M. Rust, UC Riverside or were provided to us by American Cyanamid Corp. (blank baits for Amdro and Tahara). These were exposed in the field in groups of ten baits in a choice assay consisting of a shallow circular pan, 25 cm diam x 3 cm deep, equipped with 4 holes positioned equidistant around the sides to allow the entry of foraging ants. The pans were each provided with ten small (3 cm-diam x 3 mm deep) "saucers" into which the test blank baits were placed. The bait to be placed in each saucer was preweighed to about 1000 mg. The top surfaces of the pans were covered with lids of clear plastic. For an assay, from four to six pans, each containing ten test baits arrayed at random, were placed on the soil surface in areas frequented by ants of the species to be studied. The pans were left in place for 2 to 4 hours, until observation indicated that the most favored of the test baits was being depleted by the ants. The pans were then removed from the sites and the contents of each saucer were again weighed to determine the amount of bait that had been removed by the ants.

Nearly identical tests were conducted in three different location/cropping situations for determination of bait preferences for southern fire ants. These were: in table grapes in the Coachella Valley in late April, 1995, in citrus in Tulare County in mid July, 1995, and in almonds in Kern County in mid August, 1995 (Table 1).

Similar tests were conducted for the native gray ant in citrus in Tulare County in mid August and for the Argentine ant in citrus in Ventura County in mid-September, 1995 (Table 2).

Tests for Argentine ant preferences for liquid blank baits. Argentine ants often collect honeydew from mealybugs and other soft-bodied Homopterans infesting the crop. Honeydew is a high carbohydrate, liquid material, and the most effective baits for Argentine ants might likewise be high carbohydrate liquids. To test this, an assay similar to that described above was designed, but the baits were presented to the ants in small flip-top centrifuge vials that had capacities of about 1 ml of fluid. Baits to be tested were loaded in the vials, weighed, and then presented to the ants with the vials inserted close to each other in trays made of expanded polystyrene. For each test, all baits were presented simultaneously on each tray, and the tests were replicated 5 times (5 different trays). After the ants had consumed more than 50% of the most attractive materials, the vials were collected, capped, and reweighed to determine the amount of bait materials that had been removed. For these tests, some potential toxicants - boric acid and the dye Phloxine B - were included with the carbohydrate attractive solution in some of the test vials.

Tests with baits including toxicants, plus other insecticidal methods, for control of southern fire ants in agricultural fields. A nearly identical series of three experiments was conducted in table grapes (Coachella Valley)(Table 5), almonds (Kern County)(Table 6), and citrus (Washington navel oranges)(Tulare County)(Table 7) to investigate the relative effectiveness of three bait materials vs Lorsban for control of southern fire ants in 1/4 acre plots. Amdro and Tahara both consisted of the toxicant hydramethylnon formulated on corngrit-with-soybean oil and freeze-dried silkworm pupae, respectively. Logic consisted of the IGR, fenoxycarb, formulated on corngrit and soybean oil. These three baits were applied at 1.5 pounds of formulated material per acre, being deposited in approximately 120 discrete piles of material near the bases of the plants. Lorsban, with which these bait materials were compared for efficacy, was applied by boom sprayer to the soil surface of the plots, as a full coverage spray in almonds and citrus and as a band about 2 feet both sides of the vine row in grapes. The Lorsban was applied at the rate of 2 pints per acre in grapes and 6 pints per acre in almonds and citrus, in all cases being applied in 100 gallons of water per acre. Each treatment and an untreated control were replicated 4 times in randomized complete block designs. At intervals following application, the efficacy of the treatments was determined through placing 10 open plastic vials on the soil surface near the plant rows in each plot. The vials each contained a 0.5-cm-wide slice of hot dog. The vials were placed in the plots during the morning hours. Two hours later, the vials were collected and capped. They were taken to the laboratory, where the ants were counted.

An additional test was set up in the Coachella Valley in mid October, 1995. This test consisted of three replicates, with each replicate being a whole block on each of three separate ranches. In this test, 1/4-acre blocks of Provado foliar spray (1 oz of 75% soluble solid in 200 gallons of water per acre), Lorsban soil surface spray at 2 pints in 100 gallons per acre, and Tahara bait application at 1.5 pounds per acre were made. Also, Admire at 2 pints of 4 ounce-per-gallon formulation and Enzone at 6 gallons per acre were applied to 1-acre plots in each block through the drip system. This experiment is still in operation, although preliminary counts of ants in the plots have been made already (Table 9).

RESULTS AND DISCUSSION

Tests of ant preferences for solid blank baits. Southern fire ants prefer animal (often, insect)-based baits. Amdro blanks, which are soybean oil on corngrit, and also almond oil on corngrit were less preferred than most animal-based baits (Table 1). An exception was in almond orchards, where almond oil bait was favored more than in the other cropping situations. This may be indicative of acquired tastes by the ants, with their preferences being shaped by food materials with which they are most familiar. Overall, southern fire ants appeared to favor cricket and American cockroach baits more than most other baits. Baits formulated on corngrit did not appear to be favored more or less than baits formulated on cornmeal, although high variability in our experimental results will require more replications to be conducted before definitive statements about preferences can be made. Tahara, which is the newly developed bait formulated on freeze-dried silkworm pupae, is less preferred than many of the other animal-based baits.

Native gray ants were similar to southern fire ants in their preferences, taking a number of the animal-based baits before the plant-based (especially Amdro blank) baits. Anchovy-based baits were especially preferred by native fire ants. Native gray ant preferences for Tahara ranged from fair to poor.

Argentine ants, which are usually characterized as preferring sugar-based baits to animal (lipid)-based baits, were different in their preferences from the other two species, preferring the plant-based Amdro blank over most of the animal-based baits presented to them. Of the animal-based baits, Tahara was the most preferred.

Tests for Argentine ant preferences for liquid blank baits. High sugar-based baits seem to have considerable promise for attracting Argentine ant workers to imbibe the materials and transport them to their nests. Of the various sucrose solutions tested, the highest, 50%, was the most preferred (Table 4), being about 50% more attractive than the next lower sucrose solution tested (25%) or than a 50% honey solution. Various concentrations of boric acid were tested, mixed in either 25% sucrose (Table 3, Tests 1 and 2) or 50% sucrose (Table 3, Test 3). In either case, the higher concentrations of boric acid (2%, 1%, and 0.5%) tended to inhibit acceptance by the foraging ants, while the lowest concentration tested (0.25%) was as acceptable as was the equivalent sucrose solution without boric acid. Further testing will be needed to determine whether this very low boric acid concentration is adequate to destroy whole colonies of Argentine ants. A chemical used as a dye, Phloxine B, has been seen by others to have high insecticidal activity. We included this chemical in concentrations of 0.o4, 0.08, and 0.16%, mixed in 25% sucrose solutions. None of that Phloxine B concentrations were inhibitory to Argentine ant acceptance (Table 4), leading us to further testing of this material as a toxicant against Argentine ant colonies.

Tests with baits including toxicants, plus other insecticidal methods, for control of southern fire ants in agricultural fields. The four tests of toxicant-containing baits show some common features. Tahara bait appears to be better than any other material we tested, being equal to or better than the standard, Lorsban, in controlling southern fire ants. Amdro looked equal to Tahara in effectiveness in the Coachella Valley but was inferior in the other two tests. This result must mean that the attractive feature of Amdro bait is inferior to that of Tahara, since they both contain the same toxic agent, hydramethylnon. As seen in our earlier tests using blank baits, animal-based baits, such as Tahara, appear to be superior to plant-based baits, such as Amdro, in causing foraging southern fire ants to take them to their nests. The poorer average effectiveness of the IGR, Logic, may likewise be a result of the less attractive nature of the plant-based bait, and if fenoxycarb is formulated on a more attractive bait base, it might be more effective in controlling southern fire ants. These relationships between the various materials tested are summarized in Table 8.

It is interesting that none of the materials provided effective control of southern fire ants for more than about 30 days. Further work will show whether this result is an artifact caused by small plot sizes (reinvasion of the 1/4-acre plots and re-establishment of colonies from outside sources may be occurring within 30 days), or whether the materials are only removing one generation of workers, so that few workers are left in the plots for 30 days, but, with colony reproduction intact, new generations of workers are available at the end of the 30 days. Finding a way to remove the reproductive members of the colonies so as to truly control whole colonies rather than only the worker ants is a primary goal of this work.

The experiment that is still in operation (Table 9) is aimed at the complex of ants and vine mealybugs in the Coachella Valley. More treatments will be added to this experiment, including winter dormant applications. The goal of the research is to find the effect on vine mealybugs of complete removal of ants from the treated blocks, as well as to find the effect on the ants of complete removal of vine mealybugs from the blocks. With the two species being interdependent, we will try to destroy the mutual advantage between them in a way that does not upset the equilibrium of beneficial species in the vineyard, so that natural control of the mealybugs will result.

Table 1. Bait preferences exhibited by southern fire ants in a choice-assay device.

	Amount, mg and (% of the whole pan) removed in specified crop			
Bait	Grapes	Citrus	Almonds	Means*
(Test 1)				
Anchovies on corngrit	716 (21)	95 (6)	16 (1)	(9)
Mealworms on corngrit	407 (12)	64 (4)	169 (9)	(8)
Night crawlers on corngrit	350 (10)	134 (9)	189 (10)	(10)
Crickets on corngrit	795 (23)	92 (6)	554 (30)	(20)
Am. cockroaches, corngrit	481 (14)	753 (49)	242 (13)	(25)
Amdro blank, 10-18	107 (3)	54 (4)	236 (13)	(7)
Amdro blank, 18-20	79 (2)	42 (3)	148 (8)	(4)
Almond oil on corngrit	299 (9)	24 (2)	227 (12)	(8)
Amdro blank, 5-10	168 (5)	250 (16)	21 (1)	(7)
Tahara blank	---	36 (2)	44 (2)	(2)
(Test 2)				
Anchovies on cornmeal		138 (6)	43 (6)	(6)
Mealworms on cornmeal		396 (16)	13 (2)	(9)
Crickets on cornmeal		191 (8)	212 (29)	(19)
Tahara blank		8 (0)	136 (19)	(10)
Mealworms on corngrit		111 (4)	56 (8)	(6)
Anchovies on corngrit		348 (14)	102 (14)	(14)
Am. cockroaches, corngrit		471 (19)	36(5)	(12)
Night crawlers on corngrit		644 (26)	9 (1)	(14)
Crickets on corngrit		40 (2)	34 (5)	(4)
Almond oil on corngrit		158 (6)	79 (11)	(9)

* Means in this column indicate relative bait preference, averaged over the crops tested.

Table 2. Bait preferences exhibited by Argentine ants and native gray ants in a choice-assay device.

Bait	Amount, mg and (% of the whole pan) removed in specified crop Citrus (native gray ants)	Citrus (Argentine ants)
(Test 1)		
Anchovies on corngrit	910 (30)	1 (1)
Mealworms on corngrit	384 (13)	2 (2)
Night crawlers on corngrit	282 (9)	0 (0)
Crickets on corngrit	434 (14)	0 (0)
Am. cockroaches, corngrit	427 (14)	4 (5)
Amdro blank, 10-18	32 (1)	23 (26)
Amdro blank, 18-20	17 (1)	1 (1)
Almond oil on corngrit	189 (6)	5 (1)
Amdro blank, 5-10	18 (1)	46 (51)
Tahara blank	359 (11)	11 (13)
(Test 2)		
Anchovies on cornmeal	586 (11)	1 (5)
Mealworms on cornmeal	355 (7)	0 (0)
Crickets on cornmeal	637 (12)	4 (16)
Tahara blank	215 (4)	18 (72)
Mealworms on corngrit	528 (10)	1 (3)
Anchovies on corngrit	918 (18)	1 (2)
Am. cockroaches, corngrit	586 (11)	0 (0)
Night crawlers on corngrit	410 (8)	0 (0)
Crickets on corngrit	549 (11)	0 (0)
Almond oil on corngrit	398 (8)	1 (2)

Table 3. Testing of liquid baits for acceptability to Argentine ants in a choice-assay device.

Bait	Mean amount (g) consumed in the specified test		
	Test 1	Test 2	Test 3
50% honey		0.21	0.33
25% honey		0.12	0.37
50% sucrose	0.92	0.29	0.50
25% sucrose	0.56	0.24	0.43
12.5% sucrose	0.44	0.06	0.30
6.25% sucrose	0.22	0.05	0.26
50% sucrose + 2% boric acid			0.35
50% sucrose + 1% boric acid			0.31
50% sucrose + 0.5% boric acid			0.42
50% sucrose + 0.25% boric acid			0.56
25% sucrose + 2% boric acid	0.54	0.07	
25% sucrose + 1% boric acid	0.56	0.10	
25% sucrose + 0.5% boric acid	0.57	0.09	
25% sucrose + 0.25% boric acid	1.10	0.11	
25% sucrose + 0.16% Phloxine B		0.23	0.36
25% sucrose + 0.08% Phloxine B		0.24	0.35
25% sucrose + 0.04% Phloxine B		0.24	0.38

Table 4. Testing of liquid baits for acceptability to Argentine ants in a choice-assay device; pooling of like treatments from tests 1, 2, and 3 (see Table 3).

Bait	Mean amount (g) consumed in the specified test, followed by (% of the whole test removed (in parentheses)			
	Test 1	Test 2	Test 3	Means*
50% sucrose	0.92 (19)	0.29 (28)		(24)
25% sucrose	0.56 (11)	0.24 (24)		(18)
12.5% sucrose	0.44 (9)	0.06 (6)		(8)
6.25% sucrose	0.22 (4)	0.05 (5)		(5)
25% sucrose + 2% boric acid	0.54 (11)	0.07 (7)		(9)
25% sucrose + 1% boric acid	0.56 (11)	0.10 (10)		(11)
25% sucrose + 0.5% boric acid	0.57 (11)	0.09 (9)		(10)
25% sucrose + 0.25% boric acid	1.10 (22)	0.11 (11)		(17)
50% honey		0.21 (13)	0.33 (10)	(12)
25% honey		0.12 (7)	0.37 (11)	(9)
50% sucrose		0.29 (17)	0.50 (16)	(17)
25% sucrose		0.24 (14)	0.43 (13)	(14)
12.5% sucrose		0.06 (4)	0.30 (9)	(7)
6.25% sucrose		0.05 (3)	0.26 (8)	(6)
25% sucrose + 0.16% Phloxine B		0.23 (14)	0.36 (11)	(13)
25% sucrose + 0.08% Phloxine B		0.24 (14)	0.35 (11)	(13)
25% sucrose + 0.04% Phloxine B		0.24 (14)	0.38 (12)	(13)

* Means in this column indicate relative bait preference, averaged over the crops tested in each of the above two groupings.

Table 5. Comparing baits vs Lorsban sprays for control of southern fire ants in Fantasy Seedless Grapes in the Coachella Valley. May 12, 1995.

		Mean numbers* (out of ten) of food vials containing ants and mean total numbers of ants collected per plot on indicated days following treatment						
		7	14		28		133	
Treatment	Rate	Vials	Vials	Ants	Vials	Ants	Tubes	Vials
Amdro	1.5 lbs./A	0.0a	0.0a	0a	0.0a	0a	3.1a	138a
Tahara	1.5 lbs./A	0.0a	0.0a	0a	0.0a	0a	3.7a	64a
Lorsban	2.0 pts/A	0.0a	0.0a	0a	0.7b	16b	3.5a	248a
Untreated		1.8b	3.7b	350b	3.7c	127c	2.1a	49a

* Each treatment was replicated four times. Ten hot-dog-baited vials were laid next to the bases of vines in the centers of each plot. Data recorded were the numbers of vials in each plot which contained ants at the end of two hours and the total numbers of ants in the ten vials for each plot. These data were transformed to ln(x+1) for ANOVA, and are transformed back to original units for presentation here. Any two means in the same column sharing a common letter are not significantly ($p<0.5$) according to Duncan's Multiple Range Test.

Table 6. Comparing baits vs Lorsban sprays for control of southern fire ants in almonds in Kern County. July 6, 1995.

Treatment	Rate	Mean numbers* (out of ten) of food vials containing ants and mean total numbers of ants collected per plot on indicated days following treatment					
		5	12	17		37	
		Vials	Vials	Vials	Ants	Vials	Ants
Amdro	1.5 lbs./A	0.0a	0.6ab	1.4b	22ab	2.8a	71a
Tahara	1.5 lbs./A	0.0a	0.2a	0.3a	1a	6.1a	294a
Logic	1.5 lbs./A	2.4b	5.9c	1.9b	97b	5.9a	148a
Lorsban	6.0 pts/A	0.0a	0.0a	0.4a	4a	3.8a	132a
Untreated		2.0b	2.0bc	2.1b	402c	4.3a	162a

* Each treatment was replicated four times. Ten hot-dog-baited vials were laid next to the bases of vines in the centers of each plot. Data recorded were the numbers of vials in each plot which contained ants at the end of two hours and the total numbers of ants in the ten vials for each plot. These data were transformed to ln(x+1) for ANOVA, and are transformed back to original units for presentation here. Any two means in the same column sharing a common letter are not significantly ($p<0.5$) according to Duncan's Multiple Range Test.

Table 7. Comparing baits vs Lorsban sprays for control of southern fire ants in Washington navel oranges in Tulare County. July 24, 1995.

Treatment	Rate	Mean numbers* (out of ten) of food vials containing ants and mean total numbers of ants collected per plot on indicated days following treatment					
		7	14	33		76	
		Vials	Vials	Vials	Ants	Vials	Ants
Amdro	1.5 lbs./A	1.0b	2.6b	4.3b	328c	4.4a	240a
Tahara	1.5 lbs./A	0.0a	0.3a	0.7a	10a	3.2a	143a
Logic	1.5 lbs./A	6.0c	2.5b	1.4ab	20ab	6.2a	124a
Lorsban	6.0 pts/A	0.0a	0.0a	0.4a	13a	4.1a	69a
Untreated		6.1c	3.8b	2.9b	82b	4.2a	93a

* Same as in Table 6

Table 8. Comparing baits vs Lorsban sprays for control of southern fire ants in Grapes, almonds, and navel oranges. 1995.

Treatment	Rate	Mean numbers* (out of ten) of food vials containing ants and mean total numbers of ants collected per plot averaged over all 3 southern fire ant tests, during the period from 17 to 33 days following treatment	
		Vials	Ants
Amdro	1.5 lbs./A	1.9	117
Tahara	1.5 lbs./A	0.3	4
Logic	1.5 lbs./A	1.7	59
Lorsban	6.0 pts/A	0.5	11
Untreated		2.9	204

Table 9. Comparing baits, sprays, and through-the-drip soil applications vs Lorsban sprays for control of southern fire ants in table grapes in the Coachella Valley. October 16, 1995.

Treatment	Rate	Mean numbers* (out of ten) of food vials containing ants and mean total numbers of ants collected per plot on indicated days following treatment		
		7		55
		Vials	Ants	Vials
Provado spray	1 oz 75%SP/A	0.4ab	5.3b	2.8b
Tahara bait	1.5 lbs./A	0.0a	0.0a	0.0a
Admire drip app.	2 pts/A	0.7ab	5.9b	4.3bc
Enzone drip app.	6 g/A	3.4b	347.3c	5.7c
Lorsban soil app.	2.0 pts/A	0.0a	0.0a	2.5b
Untreated		2.0b	50.5c	5.9c

* Same as in Table 6