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LABORATORY AND FIELD EVALUATION OF AVERMECTIN AGAINST THE IMPORTED FIRE ANT[1/]

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ABSTRACT

Laboratory and field tests with avermectin against the red imported fire ant *Solenopsis invicta* Buren indicated effective control at extremely low concentrations. In laboratory tests, sterility of colony queens occurred at concentrations as low as 0.0025% while death of large numbers of workers (71-100%) was obtained at concentrations of 0.025% or greater. In field tests conducted in Florida, Georgia, Louisiana and Texas, avermectin baits gave excellent control (>85%) of populations of fire ants. Also, baits formulated on pregel defatted corn grits gave much higher levels of control than baits formulated on corncob grits.

INTRODUCTION

The red imported fire ant (RIFA), *Solenopsis invicta* Buren was introduced into the United States at Mobile, AL ca. 45 yrs ago and has spread from this initial port of entry to infest all or part of 9 states and Puerto Rico. The public demand for relief from the stinging and mound-building habits caused the U.S. Congress in 1957 to appropriate funds to establish a Federal-State Cooperative Imported Fire Ant Program (Lofgren et al. 1975). Control programs for the RIFA with toxic baits began as early as 1962 (Lofgren et al. 1963, Stringer et al. 1964, Banks et al. 1973) with the baits comprised of soybean oil as a food attractant, mirex as the toxicant, and corncob grits as the carrier. In 1978, the U.S. Environmental Protection Agency cancelled registrations for all products containing mirex because of environmental residues and suspected carcinogencity (Johnson, 1976). Thus, the only registered chemicals available for control programs were those registered for individual mound treatments. This method of control is very labor intensive and would be too expensive for large agricultural areas. In an effort to find replacement toxicants for baits, USDA scientists intensified their efforts to develop new control agents.

Since 1958, USDA scientists have screened more than 7000 chemicals as bait toxicants against the RIFA. Of these, only ca. 50 have actually warrented field testing with the remainder not effective (Williams, 1983). Also, only three of the 50, mirex, Amdro® (American Cyanamid Company, Princeton, NJ) and Prodrone® (Stauffer Chemical Company, Westport, CT) have been commercially developed for public use and only the latter two chemicals are still registered. Two other chemicals, Maag RO-135223 (Maag Agrochemicals, Vero Beach, FL) and avermectin B_1 (MK-936, Merck and Company, Rahway, NJ), are expected to receive registration within the next couple of years.

The requirements used to search for effective toxicants such as mirex and Amdro were set up by Stringer et al. (1964) and Lofgren et al. (1967). The toxicants must give delayed toxicity (<15% mortality after

[1/] Mention of a commercial or proprietary product in this paper does not constitute an endorsement or recommendation of this product by the U.S.D.A.

day 1 and >85% mortality after day 14), be effective over a 10-fold dosage range, formulate with carriers easily, and be environmentally acceptable.

Standard toxicants such as mirex and Amdro provide a direct means of control by causing death of most of the colony while those chemicals that exhibit more subtle effects, but still give excellent control, may not fit all of the requirements listed above. For example, insect growth regulators such as Prodrone and Maag RO-135223 would be poor candidates for bait toxicants based on the above criteria, yet both give excellent control of RIFA in baits. Because these and other newer chemicals exert their effect by interfering with larval development or the inhibition of reproduction (Banks et al. 1978), we expanded our screening program to include tests with chemicals that produce effects other than acute toxicity on RIFA colonies.

While testing several of these novel chemicals, we discovered an experimental chemical that inhibited reproduction by RIFA queens at extremely low concentrations (Lofgren and Williams 1982). This compound was avermectin B_1a and causes irreversible cell and tissue damage to the ovaries of the queens (Glancey et al. 1982). The avermectins had previously been reported as excellent anthelminitic agents by Egerton et al. (1979).

MATERIALS AND METHODS

Avermectin B_1 (MK-936) is a mixture containing ca. 80% avermectin B_1a and ca. 20% avermectin B_1b. Initial laboratory tests were conducted with avermectin B_1a, then all later tests were conducted using the mixture avermectin B_1.

Laboratory screening procedures used were similar to those described by Williams et al. (1980a). Two types of laboratory tests are usually conducted, a primary and a secondary screening test. The primary screening test involves testing the chemicals against worker ants by holding groups of 20 workers in 30 ml cups for a 24 h period during which they are allowed to feed on soybean oil (SBO) containing the test chemical. The toxic bait is then removed, replaced with fresh untreated SBO and mortality counts recorded over a 14-day period. Tests are conducted with the chemicals at concentrations of 1.0, 0.1, and 0.01%. Chemicals giving delayed toxicity are then tested in secondary screening tests against entire laboratory colonies consisting of a queen, eggs, larvae, pupae and >40,000 workers. The test chemical is dissolved in SBO and impregnated on a carrier of pregel defatted corn grits (PDCG) produced by Lauhoff Grain Co., Danville, IL, at 30% by weight of formulation. Each colony is then given 5 g of the bait for 4 days and allowed to feed ad lib. The bait is then removed and the colonies are fed the standard laboratory diet (Williams et al. 1980b). Observations on the status of the queen, brood, and workers are recorded weekly and continued until the queen, brood, and 90% or more of the workers are dead or the colony recovers and returns to a normal condition. Check colonies are fed the bait without the toxicant and held for observations similar to the treated colonies. All chemicals that show promise at this stage are then further tested at several concentrations until the best concentrations and formulations to be used in field studies are determined.

The field tests are conducted with formulated baits prepared similarly to those used in the secondary laboratory tests. A tractor-mounted auger applicator (Williams et al. 1983) is used to apply all

baits in the field plots against natural populations of RIFA. Pre- and posttreatment evaluations are made of all active nests by opening each nest within each plot with a small shovel. The colony is then classified based on the estimated number of workers and whether worker brood is present or absent (Lofgren and Williams 1982). This rating system uses weighting factors of 1-5 for colonies without worker brood (abnormal) and 5-25 (increments of 5) for those colonies with worker brood (normal). In each case, the smaller number equals colonies with <100 worker ants and the larger number equals colonies with >50,000. A population index is calculated by summing the products of the number of colonies in each category by its appropriate weighting factor.

RESULTS AND DISCUSSION

The results of primary screening tests with avermectin B_1a are shown in Table 1. Based on the classification system devised by Lofgren et al. (1967), this chemical would not be considered as a good bait toxicant. However, because of this chemical's uniqueness, we decided to test it in secondary laboratory screening tests. The results of these tests as shown in Table 2 indicate that avermectin B_1a was extremely potent and caused death of large numbers of worker ants (71-100%) at concentrations of 0.025% or greater. In addition, sterility of RIFA queens occurred at concentrations as low as 0.0025% with death occurring at 1.0%.

TABLE 1. Results of Primary Laboratory Screening Tests Against Red Imported Fire Ants with Avermectin B_1a. (Avg. of 3 Reps. with 20 Workers/Rep.).

		% mortality on days indicated				
Toxicant	Concn(%)	1	3	6	10	14
Avermectin B_1a	0.01	3	7	8	22	43
	0.1	3	37	55	75	75
	1.0	65	77	85	93	97
Amdro	0.01	2	3	7	13	20
	0.1	2	8	68	93	100
	1.0	7	67	100		
Mirex[a/]	0.01	0	1	8	40	65
	0.1	1	18	72	96	100
	1.0	0	84	100		
SBO Check[b/]		0	0	2	3	6

a/ Avg. of 12 reps.
b/ Avg. of 15 reps.

TABLE 2. Effects of Avermectin B_1a on Laboratory Colonies of the Red Imported Fire Ant. (Two Reps. with 45,000 - 120,000 Worker Ants/Colony).[a/]

Concn (%) in soybean oil	Mortality (%) after wks indicated[c/] 1	4	8	12	16	18
	Avermectin B_1a					
0.00025	0	3	5	8	8	R
0.0025	6	13	15	25	30	QS
0.025	25	34	68	69	71	QS
0.05	48	63	72	90	92	QS
0.1	45	65	83	89	QS	
0.25	30	55	80	90	QS	
0.5	25	35	50	67	88	QS
1.0	51	81	D			
	Amdro					
0.25	38	68	D			
0.5	43	D				
1.0	88	D				
2.5	99	D				
Check[b/]	0	0	2	2	2	3

a/ Five gms of bait offered to each colony; bait consisted of 1.5 gms of SBO and toxicant impregnated on 3.5 gms of pregel defatted corn grits.
b/ Avg. 3 Reps.
c/ Fate of colony indicated at end of each column by D=died, R=recovered and QS=queen sterile.

Because of the promising effects avermectin B_1a had on queen reproduction, baits containing various concentrations of the chemical were evaluated in three field tests during 1980 and 1981 in nongrazed pastures or along roadsides in Florida and Georgia. The results shown in Table 3 indicate just how effective this chemical is at low concentrations against RIFA.

In the first test in nongrazed pastures at Jasper, FL, the 6 wk posttreatment observations revealed that all three application rates caused complete elimination of worker brood in all colonies and the population indices were reduced 90-92%.

In the second test also in nongrazed pastures at Valdosta, GA, application rates were lowered, yet after 12 wks posttreatment, 98-100% of remaining colonies did not have worker brood. The population indices were reduced 81-85% of the pretreatment value.

The third test was conducted along roadsides near Statenville, GA, and again the application rates were lowered. In fact, it was in this test that we finally saw a break in the effectiveness of avermectin B_1a against natural populations of RIFA. The two highest application rates (0.12 and 0.03 g/ha) reduced population indices 96% and 91% respectively and 100% of all remaining colonies were without worker brood. A decrease in effectiveness began to occur at the 0.0077 g/ha rate with a reduction in the population index to 85% and of the remaining colonies, 91% were without brood. Finally, the lowest application rate tested (0.0019 g/ha), gave only 56% reduction in the population index and only 25% of the remaining colonies were without brood.

In these field tests, a dramatic illustration of the effectiveness of avermectin B_1a is that of 928 RIFA colonies exposed to application rates of 0.0077 g or more/ha, only eight colonies (0.9%) contained worker brood when the final posttreatment observations were made (Lofgren and Williams 1982).

TABLE 3. Effects of Granular Soybean Oil Baits Containing Avermectin B_1 on Populations of the Red Imported Fire Ant in Florida and Georgia.[a/][b/]

Toxicant concn(%) in SBO	Application rate g AI/ha	Mean % reduction in population index after wks indicated[c/] 6	12
	Jasper, FL - April 1980		
1.06	7.41	92(100)	
0.26	1.85	90(100)	
0.07	0.49	92(100)	
Check	-	12(4)	
	Valdosta, GA - August 1980		
0.070	0.49	87(99)	85(100)
0.035	0.25	84(99)	81(99)
0.0175	0.12	84(96)	85(98)
Check	-	7(9)	0(4)
	Statenville, GA - June 1981		
0.037	0.12	96(100)	
0.009	0.03	91(100)	
0.0023	0.0077	85(91)	
0.0006	0.0019	56(25)	
Check	-	22(0)	

a/ Data from Lofgren and Williams, 1982
b/ Bait consisted of 70% pregel defatted corn grits impregnated with 30% of the SBO-toxicant solution. Application rate of formulated bait was 2.24 kg/ha at first two sites and 1.12 kg/ha at the Statenville, GA site. Avg. of three plots except five check plots were recorded in the test at Jasper, FL.
c/ Percentage of remaining colonies that did not have worker brood is indicated in parentheses.

The final step for testing avermectin B_1 baits involved large scale field tests under an Experimental Use Permit issued to Merck & Co., Inc. by the EPA. Tests were conducted in Texas, Alabama and Georgia in the fall of 1982 and in Texas, Louisiana and Georgia in the spring of 1983 by USDA, Animal Plant Health Inspection Service, Plant Pest Quarantine, Imported Fire Ant Station, Gulfport, MS. Tests were conducted in Florida in the spring of 1982 by the USDA, Agricultural Research Service, Imported Fire Ant Management Unit in Gainesville, FL. All applications of baits were made using a fixed-wing aircraft.

The results in Table 4 include only those tests conducted in the spring of 1982 (FL) and the spring of 1983 (TX, LA and GA). It is obvious from the data shown in Table 4 that the PDCG formulation was far superior to the CCG. Also, no difference occurred in the application rates with the two concentrations on PDCG.

TABLE 4. Effects of Aerial Applications of Two Granular Soybean Oil Baits Containing Avermectin B_1 on Populations of the Red Imported Fire Ant in Texas, Louisiana, Georgia and Florida.[a/]

Formulation[b/]	Application rate g of AI/ha	Mean % reduction in population index after wks indicated[c/] 6	12
0.0055% PDCG	0.055	91	96
0.011% PDCG	0.123	91	96
0.0055% CCG	0.062	64	53
0.011% CCG	0.123	80	57
Check	-	23	30

a/ Data from Texas, Louisiana and Georgia obtained from Homer L. Collins, USDA, APHIS, PPQ, Gulfport, MS.
b/ PDCG=pregel defatted corn grits and CCG=corncob grits.
c/ Population index calculated using method described by Lofgren and Williams, 1982. Data corrected for check mortality by Abbott's formula.

It is obvious that avermectin B_1 baits are highly effective as inhibitors of reproduction of RIFA queens. They do not however provide rapid elimination of the total colony and thus early posttreatment evaluations might be construed by the untrained individual that the baits failed to control RIFA. The slow elimination of RIFA colonies is probably not acceptable in areas such as playgrounds or lawns where speed is essential. However, in areas such as pastures, croplands, roadsides and other similar sites, the slow elimination of RIFA colonies would be acceptable.

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