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Evaluation of Coatings for Corncob Grit-Soybean Oil Bait Used to Control Imported Fire Ants[1,2,3]

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ABSTRACT

Thermoplastic resins, paraffin and montan waxes, liquid silicone, edible gelatins, agar-agar, sodium silicate, and polyvinyl alcohol were generally unsatisfactory as coatings for the corncob grit-soybean oil bait that is used as a carrier for mirex in control of *Solenopsis invicta* Buren and *S. richteri* Forel. Coatings of acrylic, polyvinylidene chloride, or styrene-butadiene latexes increased oil content and prolonged the field life of the bait. No coating tested was highly effective in retarding the loss of oil from bait falling on hot concrete and hot soil.

Bartlett and Lofgren (1961), Lofgren et al. (1961, 1963) and Stringer et al. (1964), after extensive studies, found that a bait formulated by dissolving the toxicant mirex in soybean oil and impregnating the solution on corncob grits was effective in eliminating from treated areas 98–100% of the established colonies of the fire ant *Solenopsis saevissima richteri* Forel (now 2 species, *S. invicta* Buren and *S. richteri* Forel). The bait was formulated easily from relatively cheap and readily obtainable materials and could be applied easily with conventional granular application equipment. Effectiveness of the bait was directly proportional to the content of oil and toxicant. However, the formulation did have some undesirable qualities. The corncob grit carrier could absorb only 15% soybean oil without becoming too oily to flow well. Also, the bait rapidly became rancid and unacceptable to the ants when it was exposed in the field to rainfall and sunlight (Bartlett unpublished report, 1962). Another undesirable quality of this formulation was that it lost oil and toxicant when exposed to dry soil or hot pavement. The low initial oil content compounded the loss of oil and toxicant and sometimes reduced effectiveness of the bait, particularly in areas where ant populations were high. As a result, the effective field life of the bait was limited to 24–48 hr.

The literature contains numerous references to the modification of preparations or formulations of pharmaceuticals, fertilizers, and pesticides to prolong their activity. Stokes et al. (1970) reviewed briefly several of these papers. Most of the reports deal with formulations in which the chemical is bound up in wax, resin, plastic, or similar material and released slowly over an extended period. Such a slow-release mechanism is unsatisfactory for the imported fire ant, because the feeding pattern of fire ants and their response to toxic baits require that essentially all the food material and toxicant be available at the time the ants first begin to feed on the bait.

The 1st efforts to discover a coating for the corncob grit-soybean oil-mirex bait were made by Lofgren et al. (1963). They were able to increase the oil content of the bait substantially (without affecting flowability) by coating the formulation with a hot gelatin solution. This formulation gave slightly better control (100%) than the original formulation (97%) in a single field test.

The technique developed by the National Cash Register Co. for microencapsulation of pathogens and insecticides (Raun and Jackson 1966) was used to develop a soybean oil-mirex bait for the fire ant that consisted of 88% soybean oil, 1.76% mirex, and 10.24% capsular wall material. Markin and Hill (1971) showed in field tests that 100 g/acre of the microencapsulated bait was equal in effectiveness to 1¼ lb/acre of the corncob grit-soybean oil bait containing 0.3% mirex. The encapsulated bait resisted the detrimental effects of weathering, and it therefore remained attractive to ants and killed them after 30 days or more of exposure outdoors (Anonymous 1969). However, it is considerably more expensive to formulate than the corncob grit bait and cannot be applied with conventional granular equipment.

Roberts (1968) discussed in detail the properties and uses of coating materials and provided guidelines for selecting the appropriate material for a particular application. His report dealt primarily with coatings for buildings, bridges, and machinery, yet it provided valuable information for our study.

Since the cost of producing the bait is a critical factor in a large-scale control or eradication program, we made studies at the Insects Affecting Man Laboratory at Gainesville, Fla., in 1969–1971 to find materials that were relatively cheap and could be applied to the formulated bait with only minor modifications to existing equipment and procedures.

Materials and Methods.—Materials were selected from numerous commercially available coating preparations. Preliminary evaluations showed that coatings in organic solvents washed most of the oil from the corncob grits and were usually unacceptable to the ants. The intensive heating necessary to cure some thermoplastic coatings made the bait unacceptable to the ants. For these reasons, we tested materials that were water miscible or heat liquescent and would dry readily when little or no heat was provided.

The 19 test materials (and the source of supply) were:

Acryloid® A-10, a thermoplastic acrylic resin, produced by Rohm & Haas.

agar-agar, granular, marketed by Arthur H. Thomas Co.

6 CP® gelatin, an edible animal gelatin produced by Burtonite Co., Inc.

Daran® 211, a polyvinylidene chloride latex with

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[3] This paper reflects the results of research only. Mention of a commercial or proprietary product or a pesticide does not constitute endorsement or recommendation by the USDA.

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60–62% solids, 0.13 μ particle size, and 1.317–1.330 sp gr, W. R. Grace & Co.

Daran® 220, a polyvinylidene chloride latex with 60–62% solids, 0.13–0.18 μ particle size, and 1.326–1.340 sp gr, W. R. Grace & Co.

Daran® X-225, a polyvinylidene chloride latex with 60–62% solids, 0.16–0.19 μ particle size and 1.326–1.340 sp gr, W. R. Grace & Co.

Dow Corning® 200 Fluid, a dimethylpolysiloxane liquid silicone, with a viscosity of 60,000 CS at 25°C, produced by Dow Corning Corp.

Durmont E®, a montan type wax produced by Dura Commodities Corp.

Dylex® K-43, a carboxylated styrene-butadiene latex with 56:44 ratio of styrene to butadiene and 51±1% solids, Sinclair-Koppers Co.

Dylex® K-45, a carboxylated styrene-butadiene latex with 62:38 ratio of styrene to butadiene and 51±1% solids, Sinclair-Koppers Co.

GAF 254, a styrene-butadiene latex with 50.8% solids produced by GAF Corp.

Knox® gelatin, an unflavored edible gelatin produced by Knox Gelatin, Inc.

Morton Polymer emulsion AA-421, an acrylic latex with 38±1% solids, 0.4 μ particle size, Morton Chemical Co.

Morton Polymer emulsion MC-299, an acrylic latex with 55±1% solids, 0.2–0.3 μ particle size, Morton Chemical Co.

paraffin wax, solid wax with 56°C mp, marketed by Fisher Scientific Products.

Piccodiene® 2215, a polydicyclopentadiene resin, Pennsylvania Industrial Chemical Corp.

Piccolyte® S-115-L, a terpene polymer resin, Pennsylvania Industrial Chemical Corp.

polyvinyl alcohol, 99% hydrolyzed with viscosity of 4% solution at 20°C of 28–32 cps marketed by Matheson, Coleman and Bell.

sodium silicate, an aqueous solution with 1.38 sp gr at 40° Baume marketed by ABC Compounding.

Since increased oil content was one of the desired improvements, the bait formulated for use with each candidate coating contained 20% oil. The formulation was prepared by heating once-refined soybean oil (200 g) containing 0.25% oil-soluble Calco® red or blue dye to 140–150°C and pouring it over 12- to 30-mesh corncob grits (800 g) as they were stirred with a kitchen food mixer (no toxicant was used). When the bait had cooled to room temperature, 1 kg was placed in a tumbler-mixer made by attaching baffles to the inside of an 11.36-liter utility can (with a removable lid) that turned on a ball mill at 40–45 rpm.

Preliminary tests, made to determine the optimum volume of coating solution and concentration of solids to provide an adequate coating, showed that the amount of solids varied, but that a volume of 10 ml/100 g of bait was adequate. This volume of each coating was sprayed as a fine mist (from a pressurized tank sprayer or hand atomizer through a 7.62-cm hole cut into the center of the mixer lid) onto the bait as it tumbled in the mixer.

Each coated formulation was then air dried, oven dried at low temperature, or exposed to the proper catalytic curing agents. After curing, preliminary evaluations were made as follows (in the order listed) to compare the coated baits with the uncoated standard bait, which contained 15% soybean oil and 85% corncob grits (no toxicant was used).

(1) Test for flowability: an 11.43-cm plastic funnel with 1.27-cm-diam spout was used as a flow meter, and the times required for 500 g of the test and the standard formulations to flow through the funnel by gravity feed were determined.

(2) Test for immediate oil displacement by water: 1 g of each test formulation and the standard formulation was placed into a small beaker of water and immediately examined under a microscope for displacement of the oil by water. Displaced oil was easily detected as bubbles.

(3) Test for acceptance by laboratory colonies of fire ants: each candidate formulation and the standard formulation were tested for acceptance by the procedure of Lofgren et al. (1961) for the evaluation of candidate foods.

Each formulation was rated in the preliminary tests as follows:

Rating	Criteria
0	Formulation unsatisfactory for use
1	Formulation inferior to standard but usable
2	Formulation equal to standard
3	Formulation superior to standard

Formulations that were rated 0 in any 1 preliminary test were discarded immediately and not tested further. Formulations that were rated 1 in any test were given the remaining preliminary test but were not considered for the secondary tests. Thus, only formulations that were rated 2 or 3 in all the preliminary tests were candidates for the secondary tests. (Ease of preparation and handling also were considered in the actual selection of materials for secondary testing, and any that were unusually difficult to use were eliminated.)

The secondary tests were:

(1) Acceptance of the fresh formulations by *S. invicta*: The dye-food technique of Bartlett and Lofgren (1961) was used for secondary tests 1 and 2 with slight modifications. Thus, 50-g lots of each candidate formulation were placed near each of 5 field colonies. After 24 hr, samples of ants were taken from each colony. One hundred ants from each sample were then crushed on absorbent paper to determine the percentage that contained dye. (The number of ants containing dye is generally related directly to the acceptability of a bait to a colony; however, acceptance will fluctuate from colony to colony depending upon hunger and availability of natural food.)

(2) Acceptance of weather formulations by the imported fire ant: 400-g lots of each formulation were exposed on each of 3 successive days in 0.61m×1.22m×10.16-cm flats to natural weathering, thus producing samples weathered for 24, 48, and 72 hr. The weathered samples were then tested for acceptance by field colonies at the same time and in the same manner as the unweathered formulations.

(3) Oil loss after suspension in water for extended periods: This secondary test was an extension of the 2nd preliminary test. One hundred g

Table 1.—Acceptance of fresh and weathered samples of latex-coated and uncoated corncob grit-soybean oil baits by field colonies of the imported fire ant.[a]

Formulation	Percentage of ants containing dye after 24-hr exposure to formulations weathered for indicated hr[b]			
	0[c]	24	48	72
AA 421 coated	45.2±8.4 a	16.0±3.1 a[d]	31.6±12.1 a	41.2± 3.3 a
Daran 211 coated	42.1±7.9 a	40.6±8.6 b	31.6± 6.5 a	43.2± 8.3 a
Dylex K-43 coated	28.0±4.8 b	29.6±7.5 c	28.8± 3.3 a[d]	39.2±13.8 a
Uncoated standard	23.6±5.5 b	4.0±2.1 d[d]	13.4± 5.0 b	12.0± [illegible] b

[a] Avg of 5 replications unless otherwise noted.
[b] Means for a given weathering period followed by same letter are not significantly different at 5% level by LSD.
[c] Fresh formulation.
[d] Avg of 4 replications.

lots of each formulation were suspended in 600 ml of water and allowed to stand for 24 hr; subsamples were removed at 8 hr. The samples removed after each period were rinsed thoroughly to remove any adhering surface oil, air dried, and extracted with hexane in a Soxhlet apparatus. The oil content was then compared with that of samples not placed in water.

(4) Oil loss after exposure to hot, dry surfaces: 36-g samples of each formulation were exposed for 18 hr on hot, dry soil and for 6 hr on hot concrete. The oil was then extracted from each sample with hexane, and the oil content was compared with that of unexposed samples.

RESULTS.—Data from preliminary tests indicated that the latexes, as a group, were the most promising materials. Except for GAF 254, all latexes equaled (rating of 2) or surpassed (rating of 3) the standard in all 3 tests. Formulations coated with latex were all free flowing, but those coated with acrylic latex were the most flowable. Resistance to immediate displacement of oil by water appeared to be about equal for all the latexes, except GAF 254, and none lost oil as rapidly as the standard except GAF 254 (which lost oil slightly faster than the standard). All latex-coated formulations were very acceptable to the laboratory colonies of ants. The GAF 254- and MC-299-coated formulations were equal to the standard, and all others were more acceptable. This increased acceptability was a reflection of increased oil content rather than any attractive quality of the latexes. The number of ants feeding on the baits indicated that the acrylic latex-coated formulations were most acceptable. However, some latexes were difficult to prepare and apply, and some failed to dry thoroughly. Therefore, since latexes within each category, i.e., acrylic, polyvinylidene, chloride, and styrene-butadiene showed promise, we selected the fastest drying and easiest applied latex from each type for further testing. Thus, bait formulations coated with AA 421 acrylic, Daran 211 polyvinylidene chloride, and Dylex K-43 styrene-butadiene latexes were exposed to the secondary tests.

Table 1 shows acceptance of fresh and weathered samples of the 3 coated baits and the uncoated standard by field colonies of the fire ant. Fresh formulations of baits coated with AA-421 and Daran 211 were significantly more acceptable to the ants than the fresh standard. Also, none of the latex-coated formulations weathered for 72 hr had a significant decline in acceptability when compared with the fresh formulations. The acceptance of the uncoated standard declined significantly after 72 hr of weathering.

Table 2 shows oil loss resulting from suspension of the baits in water for extended periods or from exposure on hot concrete or soil. The effects of extended suspension in water contrasted markedly with the effects of short exposure in water. In the preliminary test, none of the coated baits appeared to lose oil as rapidly as the uncoated standard. However, in the secondary test, the coated formulations actually lost a higher percentage of their oil content in 8 hr in water than the standard, and after 24 hr, the coated baits and the standard bait all lost about the same percentage of oil.

All coated baits exposed on hot concrete (54.5–57°C) lost considerably less oil than the uncoated standard. The bait coated with Dylex K-43 lost only

Table 2.—Loss of soybean oil from coated and uncoated corncob grit baits after suspension in water or exposure on hot concrete or sand.[a]

Formulation[b]	% of original oil lost after indicated exposure				
	Water		Concrete (6 hr)	Sand (18 hr)	
	8 hr	24 hr	54.5°C	24°C	54.5–57°C
AA-421 coated (20.7% oil)	9.2 (18.8)	11.0 (19.4)	21.3 (16.3)	22.7 (16.0)	32.4 (14.0)
Daran 211 coated (21.1% oil)	8.1 (19.4)	9.5 (19.1)	24.7 (15.9)	13.8 (18.2)	29.4 (14.9)
Dylex K-43 coated (21.5% oil)	5.1 (20.4)	9.8 (19.4)	15.0 (18.3)	10.7 (19.2)	20.5 (17.1)
Standard (uncoated) (15.5% oil)	3.2 (15.0)	9.0 (14.1)	29.7 (10.9)	17.4 (12.8)	32.3 (10.5)

[a] Avg of 3 replications.
[b] The figures in parentheses under the formulation column are the percentages of original oil in each formulation before exposure, and the figures in parentheses in the other columns are the percentages of oil remaining in the formulations after treatment.

Table 3.—Grams of oil available (per pound of bait) to imported fire ants in coated and uncoated formulations after exposure in water or on hot (54.5°C) sand or concrete (54.5–57°C).[a]

Bait formulation	Original oil content (g/lb)	Oil (g/lb) available to ants after indicated exposure[b]		
		Water	Hot sand	Hot concrete
AA-421	93.98	55.45	35.34	45.78
Daran 211	95.70	57.99	38.85	43.35
Dylex K-43	97.50	58.69	48.26	53.62
Standard	70.30	28.83	12.45	14.28

[a] Based on data in Table 2.
[b] Amount of oil that cannot be removed by ants from cob grits has been subtracted (50% for standard formulation, 30% for latex formulations).

slightly more than ½ (50.5%) as much; the AA-421 and Daran 211 coatings were somewhat less effective and lost 71.7 and 83.2%, respectively. The Dylex K-43 was the only coating that was effective in retarding loss of oil to sand—baits with this coating lost only 61.5% as much oil as the standard at ambient (24°C) and 63.5% as much to hot (54.5°C) sand. Bait coated with Daran 211 lost 79.3 and 91.0% as much as the standard to the ambient and hot sand, respectively. Bait coated with AA-421 lost more oil than the standard when the soil temperature was 24°C but about the same amount when the soil was 54.5°C.

Thus, none of the latexes were highly effective in retarding oil loss, and the principal benefit derived from the coating was the possibility of increasing the oil content of the formulation. This benefit, however, is very important because much of the oil cannot be extracted by the ants from the dense, tough grits. For example, although only 33% more oil was added to the coated baits, the amount of oil available to the ants increased by a higher percentage because all the added oil could be extracted by the ants. In subsequent studies,[5] we have found that the ants extracted an average of ca. 50% of the oil from the standard corncob grit formulation and 70% from the coated formulations.

To determine more exactly the benefit derived, we used the data from Table 2 to calculate the amount of oil actually available in each of the 4 baits for consumption by the ants after subtracting the amount retained by the grits. The results (see Table 3) showed that the amount of oil, available after the latex-coated baits were suspended in water for 24 hr, was 92–103% more than the amount available in the standard. After exposure on hot concrete and hot sand 203–275% and 184–288% more oil was available, respectively. This additional available oil makes the bait more effective and, theoretically, should permit a reduction in the rate of application or in the concentration of mirex in the bait without reducing the effectiveness.

DISCUSSION.—The latexes were the only materials that showed any real promise as coating agents for the corncob-grit soybean oil bait, although none of them were highly effective in retarding oil loss. However, the coatings did provide a method of increasing oil content while retaining good flow characteristics. They also increased the available oil by 92 to 288% although actual oil content was increased only 33%. Dylex K-43 retarded oil loss most effectively, and Daran 211 retarded it slightly less. However, subsequent formulation of large quantities of these 2 materials for field tests showed that bulk quantities were not as flowable as necessary for aerial application. Therefore, field tests were conducted only with the AA-421 formulations. Work is continuing to determine whether the flowability of the other latex formulations can be improved.

[5] W. A. Banks, C. S. Lofgren, D. P. Jouvenaz, D. P. Wojcik, and J. W. Summerlin. An improved mirex bait formulation for control of the imported fire ant. (In manuscript.)

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