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Authors
Bruggers, Richard L.
Sultana, P.
Brooks, J. E.
et al.

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PRELIMINARY INVESTIGATIONS OF THE EFFECTIVENESS OF TRIMETHACARB AS A BIRD REPELLENT IN DEVELOPING COUNTRIES

R.L. BRUGGERS, U.S. Fish and Wildlife Service, Denver Wildlife Research Center, Denver, Colorado 80225

P. SULTANA, Vertebrate Pest Section, Bangladesh Agricultural Research Institute, Dhaka, Bangladesh

J.E. BROOKS, U.S. Fish and Wildlife Service, Denver Wildlife Research Center, c/o Vertebrate Pest Control Laboratory, Dhaka, Bangladesh

L.A. FIEDLER, U.S. Fish and Wildlife Service, Denver Wildlife Research Center, c/o National Crop Protection Center, Los Banos, Philippines

M. RIMPEL, Biologist, Agronomic Research Section, Department of Agriculture, Damien, Port-au-Prince, Haiti

S. MANIKOWSKI, UNDP/FAO Quelea Project RAF 81/022, c/o UNDP, B.P. 120, Bamako, Mali

N. SHIVANARAYAN and N. SANTHAIAH, All India Coordinated Research Project on Economic Ornithology, Andrah Pradesh Agricultural University, Hyderabad 500-030, India

I. OKUNO, U.S. Fish and Wildlife Service, Denver Wildlife Research Center, Denver, Colorado 80225

ABSTRACT: Preliminary information on the effectiveness of trimethacarb as a bird repellent on broadcast seed and ripening crops was obtained during 1982 and 1983 from studies in Haiti, India, the Philippines, Bangladesh, Mali, and the United States. R50 and LD50 determinations for nine pest bird species to cereal crops in these countries indicated birds were not as sensitive to trimethacarb as to the avian repellent methiocarb. Rice and millet seed germination was not inhibited at 0.125 and 0.25% treatment levels. Wheat seed germinated well at treatments of ≤0.5% in Bangladesh. Sorghum seed did not germinate as well at any treatment level. Trimethacarb treatments on broadcast wheat seed in Bangladesh protected exposed seed from bird damage. Field trial demonstrations suggested trimethacarb applications of at least 4 kg a.i./ha to ripening grain are needed to reduce bird damage. Degradation of a 4-kg a.i./ha trimethacarb application on rice and sorghum was rapid with residue levels of 0.10 ppm and 0.68 ppm, respectively, remaining on the seed at harvest. These encouraging results, and the fact that trimethacarb is available in many developing countries, suggest that the chemical should be more extensively evaluated.

INTRODUCTION

Two chemicals, methiocarb [3-5-dimethyl-4-(methylthio) phenylcarbamate] and Curb (synergized aluminum ammonium sulfate) are presently used as bird repellents. Methiocarb is registered for several uses on agricultural crops in the U.S. (Schafer 1979) and Europe. Curb is used as corn-seed dressing and spray for buds and vegetables (Bruggers 1979). Few new chemicals are being developed as bird repellents. Demonstrating necessary efficacy data to obtain Environmental Protection Agency (EPA) registration is both a lengthy and costly process, estimated at US $15 million (Weidner 1983). Often, data show inconsistent results of repellent use. However, this paucity of bird repellents means that marketing opportunities exist for effective new materials if development costs can be met.

The purpose of our study was to evaluate trimethacarb (80% 3,4,5-trimethylphenyl methylcarbamate and 20% 2,3,5-trimethylphenyl methylcarbamate) as a bird repellent on broadcast seed and ripening grain in developing countries.

Trimethacarb is an insecticidal carbamate mixture with a toxicology spectrum similar to methiocarb. Originally developed by Shell under the trademark Landrin®, the compound was purchased by Union Carbide, who holds all rights. The common name, trimethacarb, has been approved by the American Standards Institute. All registration has been completed, and currently a 0.15% granule formulation is marketed under the name of BROOT 15-GX® as soil treatment for corn root worm (P. C. Kleyla, pers. comm.).

The Denver Wildlife Research Center (DWRC) originally screened trimethacarb in 1967 on red-winged blackbirds (Agelaius phoeniceus) and starlings (Sturnus vulgaris), determining LD50 levels of ≈10 mg/kg and >100 mg/kg, respectively (Cunningham and Schafer, unpubl. data). In an R50 test, the 1% level repelled two of five birds (Brunton, Cunningham, Schafer, unpubl. data). The compound was rated as marginal but designated for possible reconsideration. Since then, the promising results of studies showing conditioned aversion by crows (Corvus brachyrhynchos) to treated eggs (Nicholaus et al. 1983), reduction of damage to newly sown corn (Zea mays) seed by pheasants (Phasianus colchicus), and decreasing damage following topical applications to cherries (P. C. Kleyla, unpubl. data) have generated renewed interest in the compound. Presumably, if more detailed and comprehensive repellency studies demonstrate efficacy, trimethacarb will become more widely available and marketed competitively (P. C. Kleyla, pers. comm.).

METHODS

Laboratory Studies

Trimethacarb sensitivity (LD50 and R50) was determined for nine pest bird species: red-billed quelea (Quelea quelea) from Africa, house sparrows (Passer domesticus), white-rumped munias (Lonchura striata), rose-ringed parakeets (Psittacula krameri), and rock doves (Columba livia) from Bangladesh; Eurasian tree sparrows (Passer montanus), spotted munias (Lonchura punctulata), white-bellied munias (Lonchura leucogaster), and chestnut munias (Lonchura malacca) from the Philippines. All, except red-billed quelea (imported to DWRC and quarantined under USDA regulations), were trapped or purchased in their respective countries and held in communal aviaries and tested. For toxicity and repellency tests, birds were placed in individual wire-mesh cages (15 x 23 x 30 cm).

Repellency Test: We used similar test methods to Shumake et al. (1976) and Shefte et al. (1982), based on original methods of Starr et al. (1964) and Schafer and Brunton (1971). Potential test birds were fed locally available seed, usually hulled prosso millet, rice, corn grits, or chicken mash for at least one week in aviaries. After this conditioning period, each bird was pretested for 17-18 h and fed the number of seeds representing 2% of the bird's body weight. Only birds eating all seeds were tested further. Birds had continuous access to water.

Seeds for repellency tests were prepared by adding the quantity of trimethacarb required to achieve a desired application level to <5 mL of acetone or water per 100 g of seed. The mixture was shaken and vented to evaporate or dry the solvent. In no-choice tests, individual pretested birds were offered treated seeds representing 2% of its body weight for an 18-h period. Birds were then returned to communal cages containing their maintenance diet. Remaining seeds in each test cage were counted, and birds consuming less than half of the seeds were considered repelled. Birds were tested at one-half or one-fourth log intervals, depending on the results of each level, until the level at which half the test birds were repelled was bracketed. We calculated repellency indices (R50s) with 95% confidence limits (CL) by using the Thompson-Weil method (Thompson 1948, Thompson and Weil 1952, Weil 1952).

Toxicity Test: Test methodology was based on Schafer et al. (1973) and Shefte et al. (1982). Two hours before dosing, each bird was weighed and fasted until dosing time. Acute oral LD50s were determined by gavage with propylene glycol solutions of technical-grade chemical. Dose volume of the liquid administered (in µL) was twice the bird's weight (in g). A microsyringe with a short length of polyethylene tubing attached to a hypodermic needle was used to administer solutions. Tubing was introduced into the esophageal opening and gastrointestinal tract. Birds were individually caged and closely observed for several hours after dosing for signs of toxic effects, then given water and maintenance diet. They were observed during the next five days for mortality, immobility, and other signs of toxicosis; all survivors were banded and returned to communal cages.

Two birds of each species were initially used at each treatment level. Two additional birds were tested at each level when available. Survivors occasionally were retested after a minimum 2-week recovery period.

Field Studies

Demonstrations and trials with farmers and agricultural researchers were conducted during 1982 and 1983 on broadcast wheat seed and ripening rice and sorghum in Bangladesh, Haiti, Mali, India, and the Philippines (Table 1). For initial studies, we usually were obligated to work within the limitation of the trial sites provided by cooperators. Occasionally, we were able to plant or procure relatively large, independent fields.

Broadcast Seed: In Bangladesh, November 1982, treatment effectiveness on wheat of 1.0% trimethacarb, 0.5% copper oxychloride (a locally available fungicide which farmers in some districts are using as a bird repellent), and 0.25% methiocarb (percentages based on seed weight) was compared. This three-replicate trial was set up with farmers in Gazaria Thana, Dhaka District. Field size ranged from 0.25 to 0.50 ha. Pest birds were identified and counted in fields at 30-min intervals for three days following sowing. Amount of exposed wheat seed eaten in each field and number of sprouts remaining 30 days after sowing was quantified using m^2 sampling units. In addition, effect of several trimethacarb concentrations on treated seed germination and growth was determined in the laboratory. Wheat, rice, millet, and sorghum seeds were treated with different trimethacarb concentrations, dried, and immediately placed on moist filter paper in petri dishes or planted in flower pots.

Ripening Crops: In India, trimethacarb was tested as a bird repellent on 200 m^2 plots of ripening sorghum at the Agricultural College Farm, Rajendranager, Hyderabad, during both the wet season, 1982, and dry season, 1983. Using a hand sprayer, a 0.75- and 1.25-kg a.i./ha trimethacarb suspension was applied once to the heads in each plot during milk stage. Adhesives were not used in either study. Damaged and undamaged heads in each plot were counted just prior to applying the chemical and at harvest, approximately three to four weeks after spraying in each trial. Number of birds feeding in plots was counted during early morning and late afternoon for several days during the vulnerable period.

Table 1. Description of sites and application techniques used to evaluate trimethacarb as a bird repellent to broadcast seed and ripening grain during 1982 and 1983.

Crop, location, application date	No. plots Treated	No. plots Untreated	Area (ha) Treated	Area (ha) Untreated	Application techniques: Kg a.i./ha or % (each appl.)	Application techniques: No. appls.	Application techniques: Application
Broadcast seed							
Wheat							
Bangladesh							
Nov. 1982	3	3	0.25-0.50	0.25-0.50	1.0%	1	Broadcast
Ripening grain							
Sorghum							
India							
Nov. 1982	1	1	0.02	0.02	0.75, 1.25	1	Hand sprayer
Mar. 1983	1	1	0.02	0.02	0.75, 1.25	1	Hand sprayer
Haiti							
Jan. 17-26, 1983	1	1	0.15	Not used	3	1	Backpack sprayer
Philippines							
Feb. 1983	3	1	0.015-0.35	0.015	3[a]	2	Backpack sprayer
Apr. 1983	1	1	0.17	0.23	4[a]	2	Backpack sprayer
Rice							
Mali							
June 2-13, 1983	1	1	0.25	0.75	4	1	Backpack sprayer

[a] Rhoplex AC-33 adhesive also was used at the rate of 60 mL/100L of water.

In Haiti, January 1983, a 1,500-m^2 field of ripening sorghum in the soft-dough stage was sprayed at 3 kg a.i./ha using a hand pump sprayer. No adhesive was used. Effectiveness was based on pretreatment and posttreatment bird counts.

In Mali, a 2,500-m^2 plot on the edge of a 10,280 m^2 field of ripening rice was sprayed once at 4 kg a.i./ha, June 3, 1983, when rice was in milk stage. Bird counts were made at 15-min intervals between 0900-1030 and 1600-1745, once before application, and three times after spraying until June 13, when this preliminary study ended. On June 3 and 13, 10 panicles were collected from 20 randomly chosen points in each plot. Each panicle was categorized as damaged or undamaged, and seeds were removed and counted.

In the Philippines, two trials were conducted at Los Banos between February and April 1983 to evaluate trimethacarb at 3- and 4-kg a.i./ha application rates applied to ripening sorghum. In the first trial, three sorghum bands, between 150 and 350 m^2, were sprayed twice (at a 10-day interval) with trimethacarb at 3 kg a.i./ha. Trial bands and a 150-m^2 untreated band were separated by at least 50 m from each other. Experimental bands were part of a 4,174-m^2 mixed variety sorghum field. In the second trial, one 1,739-m^2 plot was sprayed with trimethacarb at 4 kg a.i./ha about two weeks after flowering; the other plot, 2,312 m^2, was left untreated. In both trials, bird counts and damage estimates were made before and after spraying. In the second trial, maximum bird numbers in each plot were determined during several 10-min periods for 22 days. In addition, 200 sorghum heads in each plot were covered with mesh bags to prevent bird damage. Stalks of another 200 exposed heads were marked with planter tags at spraying time and assessed at harvest, April 18-22, for damage.

Residue Analyses: In the Philippines, sorghum heads from fields sprayed either once or twice with trimethacarb at 3 or 4 kg a.i./ha were collected at harvest, dried in an air-conditioned room, and within 7-10 days of harvest shipped to DWRC for residue analysis. Rice samples from Haiti were collected at 1-week intervals from fields sprayed at 4 and 8 kg a.i./ha. Samples were air dried and sent to DWRC for residue analysis. Samples were frozen until analyzed four to six months later.

At DWRC, sorghum seeds were separated and analyzed separately from glume and stalk. Rice seeds and glumes were analyzed together through three weeks, the end of the milk stage. They then could be separated and analyzed separately.

The following analytical procedure was used to determine trimethacarb residues: Samples were finely ground and extracted with acetonitrile in an ultrasonic bath (10 mL acetonitrile/g of sample). An aliquot of acetonitrile extract solution containing 1-g equivalance of the sample was taken through a cleanup procedure which consisted of an acetonitrile-hexane partitioning step followed by treatment of the sample solution with Nuchar Attaclay. Trimethacarb was measured using a gas chromatograph equipped with an alkali thermionic nitrogen-phosphorous detector and a 45 cm x 2 mm id glass column of 3% OV-1 or OV-17 on 60-80M Chromosorb W, and operated at an inlet and column temperature of 125°C. Recoveries of trimethacarb from fortified samples averaged >95%. The lowest detection limit was approximately 0.1 ppm.

RESULTS AND DISCUSSION

Laboratory Studies

LD50 and R50: Sensitivity of pest bird species to chemical repellents is essential to obtain a general idea of concentration needed to protect a particular crop. Of nine pest bird species tested, only spotted munia were slightly more sensitive to trimethacarb than methiocarb (Table 2). To be effective, trimethacarb will need to be applied to ripening crops at higher rates than 2- to 3-kg a.i./ha, methiocarb's common application rate (Bruggers 1979, Bruggers et al. 1981).

Field Studies

Broadcast Seed: In replicate trials of copper oxychloride (0.5%), methiocarb (0.25%), and trimethacarb (1.0%) treatments on wheat in Bangladesh, main pests on seeds and sprouts were pied mynas (*Sturnus contra*), common mynas (*Acridotheres tristis*), pigeons (*Columba livia*), jungle crows (*Corvus macrorhynchos*), and house sparrows (*Passer domesticus*). On average, 34-52 birds visited treated fields, more birds visited untreated fields. Fields treated with copper oxychloride had the lowest bird numbers whereas fields with trimethacarb had the highest bird numbers (Table 3). However, bird numbers for trimethacarb are misleading. One myna flock, spending only a few minutes in the field before departing, caused the higher count.

Trimethacarb (17% seed loss) was more effective in protecting wheat seedlings exposed on the ground for three days in fields than either methiocarb (48% seed loss) or copper oxychloride (49% seed loss); 48% of the seed was removed in untreated fields. But sprout counts in the same fields 30 days after sowing were higher in fields treated with methiocarb and copper oxychoride than with trimethacarb. Trimethacarb-treated fields had 23% fewer sprouts than untreated fields (Table 4), indicating possible germination problems. However, despite the low sprout count, harvest yield, based on seed weight from ten 0.5 m^2 samples, was 37% greater in trimethacarb-treated than untreated fields, presumably due to growth compensation.

Table 2. Comparison of trimethacarb and methiocarb LD50 (mg/kg) and R50 (%) for several pest bird species.

Location and Species	$\bar{x}$ wt (g) of test birds	Trimethacarb		Methiocarb	
		LD50 (UCL-LCL)	R50 (UCL-LCL)	LD50 (UCL-LCL)	R50 (UCL-LCL)
Africa					
<u>Quelea quelea</u>	19.0	50.9 (97.9-26.5)	0.24 (0.40-0.14)	4.2[a] (NC)[b]	0.02 (0.01-0.02)[c]
Bangladesh					
<u>Passer domesticus</u>	21.5	33.6 (47.5-23.8)	0.22 (0.38-0.13)	14.1 (23.1-8.7)	0.11 (0.18-0.06)
<u>Lonchura striata</u>	13.1	23.8 (40.4-14.0)	0.14 (0.18-0.11)	3.5 (5.8-2.2)	0.05 (0.09-0.03)
<u>Psittacula krameri</u>	123.2	11.9 (20.2- 7.0)	0.34 (0.48-0.23)	7.1 (18.8-2.6)	0.18 (0.26-0.12)
<u>Columba livia</u>	297.0	67.3 (114.2-39.6)	0.11 (0.16-0.07)	11.9 (20.2-7.0)	0.15 (0.24-0.10)
Philippines					
<u>Passer montanus</u>	18.5	18.1 (32.7-10.1)	0.13 (0.20-0.09)		
<u>Lonchura punctulata</u>	10.5	19.6 (28.8-13.3)	0.05 (0.06-0.04)		0.06 (0.88-0.04)[d]
<u>Lonchura leucogaster</u>	11.9	10.0 (32.3- 3.1)			0.04 (0.05-0.03)[d]
<u>Lonchura malacca</u>	12.4				0.04 (0.07-0.03)[d]
Haiti					
<u>Ploceus cucullatus</u>	36.6	11.3 (14.9- 8.5)	0.14 (0.19-0.10)	7.5 (NC)[e]	0.06 (0.04-0.10)[d]
United States					
<u>Agelaius phoeniceus</u>	70	13.3[f] (NC)[f]	0.12 (0.07-0.18)[f]	4.7 (2.4-8.5)[g]	0.08 (0.05-0.16)[g]
<u>Quiscalus quiscula</u>	80	42.2[f] (NC)[f]	>1.00 (NC)[f]	10.0 (5.6-17.8)[g]	0.06 (0.02-0.18)[g]

[a] Schafer et al. (1973); [b] NC = not calculable; [c] Shumake et al. (1976); [d] Garrison and Libay (1982); [e] Shefte et al. (1982);
[f] Schafer, unpublished data; [g] Schafer and Brunton (1971).

Table 3. Average number of birds/30-min count over a 3-day period in wheat fields treated with methiocarb, copper oxychloride, and trimethacarb in Bangladesh, 1983.

Treatment (% concentration)	Replicates I	II	III	Total
Methiocarb (0.25)	20	13	12	45
Copper oxychloride (0.50)	29	0	5	34
Trimethacarb (1.00)	11	35[a]	6	52[a]
Untreated	59	51	1	111

[a] Inflated value; see text.

Table 4. Average number of wheat sprouts (n = 3 replicates) and yield at harvest from fields in Gazaria Thana, Bangladesh, 1982.

Treatment (% concentration)	Avg % of potential sprouts[a]	Avg yield/m^2 (g)	% increase in yield over untreated
Methiocarb (0.25)	58.0	145.3	+ 3.1
Copper oxychloride (0.50)	46.4	173.2	+23.0
Trimethacarb (1.00)	32.8	193.0	+37.0
Untreated	42.7	140.0	-

[a] % potential = % of total seeds sown/m^2 germinating 15-30 days later.

Our laboratory studies also indicated high trimethacarb application levels can adversely affect some seed germination. Trimethacarb, particularly at 2%, and somewhat at 1% concentrations, reduced wheat germination in petri dishes and flower pots in Bangladesh (Table 5). Sprout numbers of 2% trimethacarb-treated seed were less than untreated seed in pot trials (Table 5). Likewise, combined data from four seed types treated with trimethacarb (levels averaged over seed type) at DWRC showed a constant decrease in germination as trimethacarb concentrations increased. A significant relationship ($P < 0.05$, Duncan's multiple range test) occurred between untreated seeds and all levels of treated seeds, except 0.125%. Difference among grains was noted. Wheat and rice germination was less affected by treatment level ($P < 0.05$, two-way ANOVA) than millet and sorghum (Fig. 1, Table 6). Heisterberg (pers. comm.) also observed reduced germination of corn seeds treated with 0.27% trimethacarb. No difference in germination was apparent between 0.25 and 0.50% levels (Table 6).

Table 5. Average percent germination and average number of sprouts/flower pot of wheat seed treated with different trimethacarb concentrations in Bangladesh. Counts were made two weeks after sowing.

Conc. (%)	Avg % germination (range)[a]	$\bar{x}$ no. sprouts/pot[a]
0.25	87 (85- 90)	15
0.50	97 (95-100)	13
1.00	82 (75- 90)	15
2.00	43 (35- 50)	7
Untreated	98 (95-100)	11

[a] Based on 3 replicates of 20 seeds in each petri dish and flower pot.

Table 6. Average number of seeds germinating following treatment with different trimethacarb concentrations, June 1983, DWRC.

Conc. (%)	Wheat		Rice		Millet		Sorghum	
	Jul 5	Jul 7	Jul 5	Jul 7	Jul 5	Jul 7	Jul 5	Jul 7
0.125	15	15	15	19	20	20	11	11
0.250	7	14	19	19	18	18	10	11
0.500	10	13	14	17	16	16	6	6
1.000	5	8	8	14	9	11	2	2
Untreated	20	20	20	20	20	20	16	16

[a] Based on 3 replicates (20 seeds/replicates/treatment level). Seeds were counted 7 and 9 days after being placed in petri dishes.

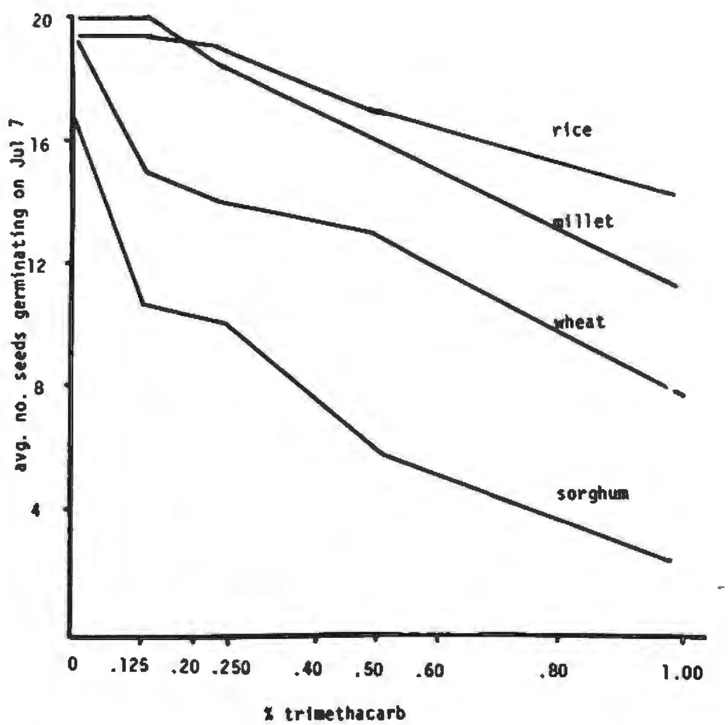

Fig. 1. Average number of seeds germinating in petri dishes nine days after treatment with different concentrations (0.125, 0.250, 0.50 and 1.0%) trimethacarb.

At levels >1.0%, germination in all four seed varieties was significantly retarded ($P < 0.05$, two-way ANOVA; Duncan's multiple range test) compared to untreated seeds (Tables 5 and 6). All untreated seed had germinated by 5 July, but treated seed had not completely germinated until 7 July.

Ripening Crops: In India during the wet season trial in 1982, 20 to 25 Indian baya (Ploceus philippinus) and munias (Lonchura spp.) damaged the sorghum plot daily for seven days following chemical application. As the crop reached early dough and mature stages, 15-20 of both Indian mynas (Aeridotheres tristis) and house crows (Corvus splendens) were present daily in the field until harvest. Although actual yields were about six times greater in treated plots than untreated plot, all three plots suffered severe damage. Treated plot yields of 4.1 and 4.8 kg/0.02 ha and untreated plot yield of 0.7 kg/0.02 ha were extrapolated to 200-250 kg/ha within treated plots and about 75 kg/ha in the untreated plot (Table 7). Severe damage was attributed to rains washing chemical from grain (no adhesive was used) and inadequate application rate for larger birds such as crows.

Table 7. Sorghum yield (kg/0.02 ha) following one trimethacarb (0.75 kg a.i./ha or 1.25 kg a.i./ha) application to ripening sorghum (all plots = 0.02 ha), Hyderabad, India, during the wet and dry season.

Season	Date	Application rate (kg a.i./ha)	Actual yield (kg/0.02 ha)
Wet	Oct. 1982	0.75	4.1
		1.25	4.8
		Untreated	0.7
Dry	Feb. 1983	0.75	34.0
		1.25	35.0
		Untreated	26.0

In the dry season, however, 0.75 and 1.25 kg a.i./ha trimethacarb applications performed better, giving extrapolated yields 1.5 times greater (1,700-1,750 kg/ha) in treated plots than the untreated (1,300 kg/ha) plot. Overall damage was also less than during the wet season. The crop was damaged by only a few Indian mynas and house crows; Indian bayas and munias were not observed.

Two pilot studies, in different seasons, suggest trimethacarb application can reduce bird damage to ripening sorghum. However, more work on pest bird species' sensitivity to the chemicals, application rate, and number of necessary applications would be desirable.

In Haiti, 3-kg a.i./ha trimethacarb application did not provide satisfactory protection. Prior to the spraying at 0830, January 26, 80-150 yellow-faced grassquits (Tiaris olivacea) and about 50 village weavers (Ploceus cucullatus) were feeding regularly in the field. For several days following spraying, grassquits ceased feeding in fields. However, village weaver population numbers remained high during the two days following application (Table 8). Trimethacarb was applied only once and the field eventually was nearly destroyed by birds. Trimethacarb applications of 3 kg a.i./ha seemed to repel grassquits but higher rates, perhaps 4 or 5 kg a.i./ha, or additional applications are needed to repel village weavers. However, the chemical had been applied after damage started, and it is extremely difficult to stop birds from damaging fields after feeding patterns have been established.

Table 8. Average number of birds feeding in a mature sorghum field on different dates following trimethacarb application at 3 kg a.i./ha, January 26, Haiti.

Species	Jan. 17-15	Jan. 26[a]	Jan. 26	Jan. 27	Jan. 28	Jan. 29 - Feb. 4
Grassquits	75	80-150	5	0	0	1
Village weavers	30	50	15	14	38	9

[a] Counts made during previous week and morning before trimethacarb was applied.

In trials in the Philippines, 3 kg a.i./ha trimethacarb applications also provided only limited protection. Eurasian tree sparrows, though fewer numbers, continued to visit treated sorghum plots. At the trial's conclusion, damage was 1.5 times greater in treated plots and 1.3 times greater in the untreated plot compared to pretreatment levels (Table 9). These discouraging results may have been caused by: some of the 50% WP settling out of suspension in the 10-L spray tanks of backpack sprayers; lack of individual, isolated plots; an insufficient application rate; or, as in Haiti, presence of birds and damage at the time plots were sprayed. In addition, R50 studies showed that Eurasian tree sparrows (R50 = 0.13), principal pest in the first trial, were not as sensitive to trimethacarb as spotted munias (R50 = 0.06). These problems were not obvious in our second trial. Spray was applied with constant agitation at 4 kg a.i./ha and with considerably better results (Table 10). Sorghum yield at harvest was almost 500 kg/ha greater in the treated than untreated plot, despite larger and heavier average head size in the untreated plot. Birds also stopped feeding in the treated plot, some apparently moving to the untreated plot (Fig. 2).

Table 9. Total daily number of Eurasian tree sparrows and percent damage (visually estimated) to ripening sorghum before and after trimethacarb application[a] at 3 kg a.i./ha, Los Banos, Philippines, 1983.

		Total birds/day[b]			% damage		
	Size	Pretreatment	Posttreatment		Pretreatment	Posttreatment	
Bands	(m^2)	Feb. 22-24	Feb. 25-Mar. 7	Mar. 8-11	Feb. 25	Mar. 7	Mar. 15
Treated							
17-18	150	8	14	6	0	27	29
31-33	225	46	8	1	25	42	43
58	350	28	3	0	12	28	31
Total/Avg	725	27	9	2	16	32	34
Untreated							
9-10 only	150	0	0	6	8	7	11
All other	3,299	71	67	59	-	-	-

[a] Trimethacarb applications were made on Feb. 25 and Mar. 7.

[b] Total Eurasian tree sparrows counted in each band at four 30-min. intervals between 0800-1000 and again at 1500-1700.

Table 10. Comparison of bird damage in a vulnerable sorghum field sprayed twice (Mar. 23 and Apr. 6) with trimethacarb at 4 kg a.i./ha and fields left untreated, Los Banos, Philippines. Data are based on samples of about 200 heads in each plot.

	% damage		Actual yield	$\bar{x}$ harvest wt (g)		$\bar{x}$ head length
Plot	Mar. 24	Apr. 14	(kg/ha)	Uncovered	Covered	(cm)
No. 8 - Treated	6	7	1,770	21	26	16
No. 7 - Untreated	2	14	1,280	28	34	17

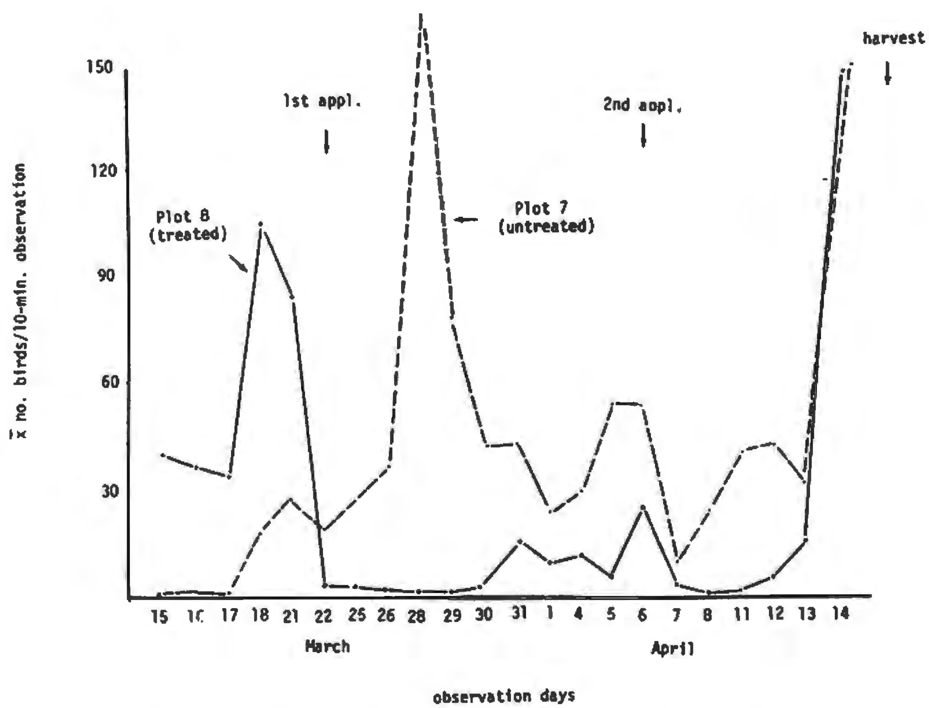

Fig. 2. Average number of birds observed feeding in a trimethacarb-treated and untreated plot in Los Banos, Philippines, based on the maximum number of birds observed each 10-min. interval.

In Mali, a 4-kg a.i./ha trimethacarb application seemed to protect ripening rice for the 10-day rainless test period. Overall damage increased an additional 3.3% in the treated plot and 10.4% in the untreated plot (Table 11). Both plots had >40% damage incidence when the chemical was first applied. The incidence of damage to ripening heads increased in both plots to >65%, presumably due to arrival of new birds in the area and/or resident birds constantly sampling in their search for food (Jaeger et al. 1984). Total bird counts from four days during the trial were higher in treated (1,357 birds) than untreated plots (939 birds). Feeding flocks were comprised primarily of red-billed quelea (70%) and bishops (Euplectes spp.) (30%).

Table 11. Bird damage to ripening rice, Mali, June 1983. Two hundred randomly selected panicles were assessed for damage in each plot, immediately before and 10 days after a 4-kg a.i./ha trimethacarb application.

	Trimethacarb-treated plot		Untreated plot	
	Prespray	Postspray	Prespray	Postspray
% incidence[a]	40.7	69.4	49.2	65.7
% damaged seeds from damaged panicles[b]	19.6	16.3	18.0	29.4
Overall damage (% incidence x % damage/100)	8.0	11.3	8.9	19.3

[a] Percentage of damaged panicles in sample.

[b] Percentage of total number damaged seeds in sample.

Residue analysis: Trimethacarb degraded rapidly on rice samples from Haiti (Table 12). Following 4- and 8-kg a.i./ha application rates, average residues of 9.4 ppm and 465 ppm, respectively, declined to 0.1 ppm on the seed (both application levels at harvest. Discrepancy between residue levels immediately after application may have been caused by contamination or poor sampling procedures. However, the degradation pattern for both levels is initially rapid, similar, and thereafter like the pattern found for a 2-kg a.i./ha application of methiocarb (Gras et al. 1981). Half-life was 5.2 days for the 4-kg a.i./ha application and 4.2 days for the 8 kg a.i./ha application compared to six to seven days for a 2-kg a.i./ha methiocarb application (Gras et al. 1981). Residues exceeding the R50 of most bird pests were on both seeds/glume samples and the seeds only at 21 days after spraying. The amount of chemical on the seed at harvest was far less than the amount shown to inhibit germination; therefore, sprayed seeds could be used as seed stock without fear of reduced germination.

Table 12. Persistence (ppm) of 4- and 8-kg a.i./ha trimethacarb applications on rice, Haiti, 1983. Residues are averages of two to four samples/plot.

Days after spraying	Application rate			
	4 kg a.i./ha		8 kg a.i./ha	
	Seed & glume	Seed only	Seed & glume	Seed only
0	9.4	Not analyzed	465.0[a]	Not analyzed
7	4.4	Not analyzed	22.0	Not analyzed
14	2.0	Not analyzed	2.8	Not analyzed
21	3.0	0.3	3.9	0.4
28	0.1	3.5	3.5	0.1

[a] Included in half-life calculation for 8 kg a.i./ha application rates.

At harvest, residues on sorghum seed treated in the Philippines at 3 kg a.i./ha were 0.18 ppm; at 4 kg were either 0.42 or 0.68 ppm depending on the plot (Table 13). Comparable residues were found on seed treated either once or twice at 4 kg a.i./ha. Harvest residue levels were similar to those found on rice in Haiti.

Table 13. Trimethacarb residues remaining on the seed and glume/stalk of sorghum collected at harvest and about four weeks after the application and two weeks following second application, Los Banos, Philippines, 1983.

Plot	No. applications	Application rate (kg a.i./ha)	Date		Trimethacarb (ppm)[a]	
			Spray	Collection	Seed	Glume/stalk
5	1	4	Mar. 23	Apr. 18	0.68	7.40
8	2	4	Mar. 23, Apr. 6	Apr. 21	0.42	9.60
11	1	3	Apr. 6	May 5	0.18	0.76
6	Untreated	0	-	May 3	ND[b]	ND
7	Untreated	0	-	Apr. 21	ND	ND

[a] Based on the major isomer 3,4,5 trimethacarb. The 2,3,5 isomer was not apparent in samples.

[b] ND = None detected.

CONCLUSIONS

We feel evaluation of trimethacarb on cereal crops should continue. Trimethacarb seems to repel birds, particularly smaller species such as munias and grassquits. However, most species tested were less sensitive to trimethacarb than methiocarb. Based on this information and field test results, it seems more than one application of at least 4 kg a.i./ha may be needed to protect a crop during the vulnerable period. Bird numbers seem to rebuild seven to ten days after application. The chemical degraded rapidly leaving residues on sorghum seed of 0.68 ppm following the 4-kg a.i./ha application (with an adhesive), and on rice seed (without an adhesive) of 0.10 ppm at harvest. When used as a treatment to newly sown seed, it should be applied at <0.50% to avoid inhibiting germination or retarding growth.

Chemical repellents will probably not take the place of lethal control to reduce crop damage by quelea in Africa. But there are many situations in the world in which chemical repellents can be used alone or with lethal control to protect crops (Erickson et al. 1980, Bruggers and Jaeger 1982). In countries not experiencing the severe bird pressure to crops occurring in many African countries, chemical repellents could be very useful to individual farmers, agronomists at research stations, and individuals at seed multiplication or production schemes. However, a major drawback has been the unavailability of repellents in many countries. If proven consistently effective under more rigid test designs, and marketed at competitive prices, trimethacarb has possibility for widespread use because of the existing worldwide distribution network of the manufacturer.

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