EVALUATING THE BIRD REPELLENCY OF METHIOCARB

by M. Hamza, B. Ali, I. El Haig, W. Bohl,
J. Besser, J. De Grazio, and R. L. Bruggers

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INTRODUCTION

The Red-billed Quelea *Quelea quelea*, while only one of the many ploceid weaver pest species in Africa, is probably the most numerous avian species in the world, and perhaps the most destructive. It ranges over floodplains in semiarid parts of Africa south of the Sahara (Magor 1974), inhabiting about 20% of the land area and adversely affecting the economies of 25 nations (De Grazio 1978). In Sudan, it occupies about 90% of the country's grain production areas and is responsible for damage to sorghum, rice, and wheat.

Because traditional farmers suffer a disproportionate share of the total bird damage compared with large cereal schemes, economical, simple, and appropriate methods of bird damage control are necessary for small plantings. This report summarizes the fieldwork accomplished in Sudan, Kenya, and Tanzania on the use and effectiveness of the chemical methiocarb (4-methylthio-3,5,-xylyl N-methylcarbamate) as a bird repellent on broadcast seed and ripening grain. Methiocarb is widely used and registered for several crop application uses in the United States as a bird repellent and has been tested recently in Senegal (Bruggers 1979) and East Africa (Bruggers *et al.* 1981). At low levels of R_{50} = 0.015% to 0.178% (Shumake *et al.* 1976; Shefte 1982), it is a repellent to Red-billed Quelea, the principal bird pest in Africa, and other pest species in Sudan like Village Weavers *Ploceus cucullatus*, Red Bishops *Euplectes orix*, Golden Sparrows *Passer luteus*, and Masked Weavers *Ploceus taeniopterus*. Methiocarb is thought to repel birds by causing an illness-induced conditioned aversion (Rogers 1974, 1978).

METHODS

Ripening grain application

Demonstrations and trials were conducted between 1977 and 1980 with farmers and agricultural researchers on ripening sorghum, millet, and wheat in several provinces of Sudan. Repellency was evaluated for several bird species in wire or net enclosures of 2 m^3 to 8 m^3 placed over ripening crops and on entire fields of vulnerable cereal crops. Exposed cereal heads in the cages or in small fields were sprayed with portable Handi sprayers, B & M sprayers, and motorized CP3 knapsack sprayers; large fields were sprayed using aircraft. In all enclosure studies, the birds were introduced after the heads had been sprayed. Additional treatment details for certain specific tests are described under results. Replications were used whenever possible.

Broadcast seed treatment

The trial was conducted at the Agricultural Research Corporation (ARC) station at Wad Medani. Two replicate 600 m^2 adjacent bands in each of two 4.3 ha ricefields were seeded at a rate of 77 kg/ha. The seed for one of each pair of bands was treated with methiocarb (0.20% by seed weight), and Rhoplex AC 33 adhesives (48% solids -- 0.10% by seed weight) in a water solution in a barrel mixer, sun-dried (water evaporated), and handsown into 7.5 to 10.0 cm furrows and covered with 2-3 cm of soil. The fields were irrigated after seven days, simulating planting conditions at the Gezira Scheme. Counts were made of the proportion of damaged to undamaged seeds, the number of plants in a 625 cm^2 sampling unit, and the number of birds feeding in the trial fields during peak activity periods. Seeds and seedlings were collected for residue analysis.

RESULTS AND DISCUSSION

Ripening grain application

The initial work with methiocarb in Sudan was considered either promising (Martin & Jackson 1977) or inconclusive due to insufficient bird pressure (Martin 1976). Since 1977 several other field trials and enclosure studies have been conducted in Sudan to evaluate further the effectiveness of methiocarb as a means of reducing damage by queleas and other birds to cereals.

Enclosure tests In a test near Jodah (coord. 12°30'N x 33°0'E), in which queleas and Village Weavers were placed in net enclosures in a sorghum field with alternative food, excellent protection was achieved with 1 to 3 kg of methiocarb/ha head sprays (Table 1). In this test, each head was treated with 5 cm^3 of either a 0.09% or a 0.27% methiocarb suspension with a B & M sprayer. No more than 2.6% damage occurred in the treated enclosures compared with 42.6% in the untreated enclosure (Table 1). Damage was from 16 to 41 times greater in the untreated enclosure and the yield was from 94% to 98% less. The birds consumed from 20 to 43 g of alternative food in the untreated enclosures compared with 60 g in the treated enclosure. Methiocarb was toxic to both species, particularly at the 3 kg/ha level (estimated 200 ppm residue level), as 43% of the 54 Village Weavers and 30% of the 40 queleas died; only 3% of the 41 queleas died at the 1 kg/ha rate. The mortalities indicate that low levels of methiocarb should be used and probably would be effective in repelling queleas and Masked Weavers. Methiocarb has been an effective, broad-spectrum, and nonlethal repellent to many bird pests in many countries (Guarino 1972, Crase & DeHaven 1976, Calvi *et al.* 1976).

Aerial application In October 1977, at Hawata (coord. 13°28'N x 34°38'E), an aerial application of 4 kg/ha of methiocarb, by a Piper Supercub with booms, with 1 kg/ha of an acrylic resin adhesive, Encryl E, on three plots of 4 ha each of sorghum did not provide protection because of application problems. Studies with birds put in enclosures in one of the aerially sprayed fields confirmed that the spray was ineffective in the manner applied. However, the same concentration, when applied to sorghum with a knapsack sprayer, resulted in good protection.

Table 1 Protection of ripening heads of dura sorghum in 8-m^3 enclosures sprayed with methiocarb at Jodah, Upper Nile Province, Sudan; November 1978

Treatment rate (kg/ha)	No. birds per enclosure	Species	% damage*
3	54	Village weaver	1.4^a
3	40	Quelea	0.9^a
1	41	Quelea	2.6^a
Untreated	40	Quelea	42.6^b

* Significant difference (*P* < 0.05; *t*-test) occurred between damage percentages with different superscripts

Table 2 Crop damage and bird pressure in wheatfields treated with methiocarb in Kenya, Tanzania, and Sudan

Location		Untreated field	Treated field
Nanyuki, Kenya	No. damaged heads/1,000	493	60
	No. birds/observation		
	before treatment	612	1,278
	after treatment	629	182
Rujewa, Tanzania	No. damaged heads/1,000	510	50
	No. birds/observation		
	before treatment	65	32
	after treatment	174	39
Shambat, Sudan	Plot 1		
	No. damaged heads/1,000	116	31
	Avg no. birds/observation	54	3
	Plot 2		
	No. damaged heads/1,000	46	53
	Avg no. birds/observation	463	22

Table 3 Comparison of the effectiveness of complete and edge-only methiocarb applications to four varieties of ripening wheat at Shambat, Khartoum; February 1980

		Spray coverage			
		Complete		Edge	
	Replicates	% loss	Yield (kg/32 m^2)	% loss	Yield (kg/32 m^2)
Mex XG 155 L2 75/76	1	0	9.5	0	7.9
	2	8.0	9.7	5.0	8.1
Son 64 XC - 271	1	8.0	10.1	5.0	10.9
	2	10.0	9.3	0.0	9.6
Mex XG 155 L15 75/76	1	0	10.7	0	9.2
	2*	-	-	10.0	9.5
	3*	-	-	5.0	8.6
Average		3.7	9.8	3.6	9.1

* Only one complete-spray coverage plot

Table 4 Residues of methiocarb and its sulfoxide and sulfone metabolites (in ppm) from a 0.20% seed dressing treatment (by seed weight) of rice seed in Sudan, June 1980

Growth stage	Time (days)	Methiocarb	Methiocarb	Sulfoxide	Sulfone
Presowing	0	0.11%	-	-	-
Nongerminated	10	2	9 and 12	<1	<1
Seedlings	15	2	<1	<1	<2
Seedlings	20	3	1	<1	<2
Seedlings	25	<1	<1	<1	<1

Field tests Studies demonstrating the repellency of methiocarb to pest birds also were carried out on sorghum, millet, and wheat at ARC field stations at Shambat (coord. 15°35'N x 32°30'E), and Wad Medani (coord. 14°23'N x 33°32'E). Applications of 2% and 6% methiocarb sprays to individual heads of sorghum along one edge, and two days later the remaining edges of a 0.1 ha field, markedly reduced the number of birds feeding on the heads in the field during the first few days. Heads sprayed with either concentration were not eaten. Birds repelled included House Sparrows *Passer domesticus*, and weaver birds of the genera *Ploceus* and *Euplectes*. However, the technique did not protect the remainder of the field; birds soon began returning, and after one to two weeks, only the sprayed heads in the field were not completely eaten.

A similar application of 2% and 6% methiocarb on vulnerable heads of ripening millet resulted in a decrease in the number of *Ploceus* spp. feeding on the millet from about 300 birds to fewer than 50 the day after application. The bird population built up again following 6 mm of rain, which presumably washed off the methiocarb since no adhesive was used. Respraying the heads again reduced the numbers of *Ploceus* from several hundred to less than 50 birds a day.

Several additional methiocarb demonstrations were conducted in East Africa (De Grazio & DeHaven 1974). At Nanyuki (coord. 0°1'N x 37°7'E), Kenya, during January 1974, one of two 1/8 ha plots of ripening wheat was sprayed with methiocarb and a 0.5% latex adhesive solution at the rate of 3 kg/ha. Sixteen days after application, bird damage was eight times greater on the untreated than treated plot. Observations on and near the wheat plots before treatment indicated twice as many birds in the area to be treated than in the untreated area. Observations after treatment showed the reverse; about three times more birds in the untreated than in the treated plot (Table 2). Many birds had apparently left the area. Queleas, Chestnut Weavers *Ploceus rubiginosus*, and Long-tailed Whydah *Euplectes progne* were the most obvious pests.

Another demonstration was conducted at Rujewa (coord. 8°54'S x 33°27'E), Tanzania, in February 1974 on one of two 0.05 ha plots in a 1.2 ha field with the same application methods and rates as the previous test. After three days, bird damage was 10 times greater in the untreated than treated plot. Bird pressure also increased on the untreated plot compared to the treated plot (Table 2).

As a consequence of the encouraging results obtained in some of these preliminary tests, we decided in 1980 to determine the effectiveness of an edge spray in protecting an entire field (edge applications being more feasible economically than whole-field applications). In a trial at Shambat, Sudan, methiocarb was applied at the rate of 1 kg/ha to the outer edge (1/3 the area) of two 0.25 ha fields of ripening wheat during the milk stage and again 10 days later during the soft-dough stage. Two similar size fields were left untreated. Bird pressure and damage were monitored weekly. Each treated field was less damaged than its untreated pair, and from 18 to 20 times more birds were counted in the untreated than treated fields (Table 2).

In a second demonstration, also at Shambat during 1980, methiocarb was applied to experimental national wheat variety plantings. All heads in 11 of 70 32 m^2 plots (352 m^2 total) were individually sprayed with a total of 1.3 kg of methiocarb and 16 l of water; adhesive was not used. The edge rows of three other 32 m^2 plots also were sprayed to compare the effectiveness of edge and complete coverage applications. Bird damage was estimated visually before spraying and just before harvesting. Effectiveness comparisons were made using yield and damage patterns of wheat grown at Shambat during the same period in the previous two years when methiocarb was not used. Bird counts were conducted before and after methiocarb was applied.

Methiocarb repelled House Sparrows, bishops, and *Ploceus* weavers; the number in the study plots decreased from an average of 73 per 10 min observation period during the three days before treatment to less than one bird per observation period during the two days immediately following application. Ten days later there were still less than two birds per observation period, on average. The reduced number of birds resulted in an average of only 2.9% loss in the 14 plots, compared with 5.6% in 12 plots in 1978/79 when methiocarb was not used.

Five varieties of wheat grown in 1979/80 also were planted in 1977/78 and 1978/79. Four of these varieties (Son 64 XC-271, Condor, Pato Argentina, Nayab 70) were less damaged in 1979/80 than in the two previous years. Finally, no significant differences ($P < 0.05$; t-test) occurred between the yields of edge-sprayed and completely sprayed plots (Table 3), again supporting the feasibility of the less expensive edge application methods.

Dabar variety sorghum is not an easy crop to protect because (a) it has small seeds (not unlike millet), (b) the grains do not protrude far from the glumes so that less chemical repellent is present on the surface areas of grains that queleas attack, (c) queleas attack it immediately after the flowering stage, (d) stands are sparse (ca 5,000 plants/ha), and (e) stands often ripen unevenly. This last situation makes a spot spray to the first ripening heads particularly appealing. For example, when the first 1% of the heads are in the dough stage and under bird attack while others are still in flower, these few maturing heads could be sprayed by villagers with a repellent.

Broadcast seed treatment

Methiocarb was effective in West Africa as a seed dressing for reducing bird losses to broadcast rice (Bruggers 1979). Farmers at the Gezira Scheme in Sudan sow their fields at rates of 77 to 110 kg/ha to compensate for various causes of nongermination, including bird damage which can be so high that some fields have to be entirely resown. Using a bird repellent can provide a technique whereby farmers can sow at reduced rates and probably also eliminate the necessity to resow.

In the one seed dressing trial conducted in Sudan, the main birds eating the newly sown rice were Chestnut Sparrow Larks *Eremopterix leucotis* and Crested Larks *Galerida cristata*. They were part of a small resident population and averaged only 10-20 Sparrow Larks and 3-5 Crested Larks per day in the area; three-quarters of the visits were to untreated plots. No queleas or Golden Sparrows visited the fields, although both species were in the area during the study.

The proportion of damaged seeds was 3.8 times greater in the untreated plots than in the treated plots (averages of 16.9% and 4.4%). The rate of seedling survival, 17 per sampling unit in the treated and 15 per sampling unit in the untreated plots, was about the same due to displacement of seeds during flooding, incidence of ungerminated seeds, and uneven distribution of seeds on and below soil. The trial demonstrated that methiocarb can reduce rice seed damage to larks; similar results were obtained in 1977 with these species in a trial on melon seeds in Senegal (Bruggers).

Residue analysis

Ripening grain: Residues averaging 74.6 ppm were found on heads of wheat (seed and glume) 10 days after treating with 3 kg/ha of methiocarb in Sudan. These are less than the 102 ppm found on sorghum in Senegal (seed and glume) for the same time period following a 2 kg/ha application (Gras *et al.* 1981). Residues on the seed itself would be expected to be even less than the 3.0 ppm found on sorghum after 25 days since the wheat seed is completely covered throughout maturation. More detailed chronological residue analyses are needed for ripening grains.

Broadcast seed: Seed and seedling samples for residue analysis of methiocarb and its sulfoxide and sulfone metabolites were obtained by randomly collecting at least 300 seeds or seedlings immediately after the chemical was applied and at days 10 (after irrigation), 15, 20, and 25 (when the plants were between 10 and 15 cm in height). The samples were immediately frozen and sent by air to the Denver Wildlife Research Center (DWRC) Chemical Research Laboratories. The samples were analyzed by the procedure of Greenhalgh *et al.* (1976). A portion of each sample was analyzed 'wet' as received at the laboratory. The rest of the samples were dried, analyzed, and corrected to the wet weight basis. The results are presented in Table 4. Methiocarb residues from the dried samples were all < 1 ppm after 15 days indicating no toxicity hazards. Differences of only 1-2 ppm were found between the wet and dry samples. The chemical already is registered in the U.S. for several fruit and grain crops at much higher levels of 15-25 ppm (Schafer 1979).

CONCLUSIONS

Our results indicate that late dough-stage sorghum (dura variety) can be protected initially at application rates as low as 1 kg/ha when sprays are directed only at the heads. This probably is near optimum effectiveness as the residue level at this concentration was computed to be about 65 ppm.

These results, supported by more detailed tests on the role of adhesives in Texas (Besser & Elias 1979), suggest that the acrylic resin, Rhoplex AC-33, when used at one part adhesive solids to three parts methiocarb solids, probably interferes with or masks the repellent properties of methiocarb. When adhesives are used in spray treatments in very dry climates, such as in Sudan, ratios of at least one part adhesive to 10 parts methiocarb should be used.

Although the results of these studies are encouraging, additional field-word testing, particularly with farmers, is necessary to further delineate the conditions under which methiocarb can be recommended as a crop protection method.

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M. Hamza, B. Ali, I. El Haig, Department of Plant Protection, Ministry of Agriculture, Khartoum, Sudan

and

W. Bohl, J. Besser, J. De Grazio, R. Bruggers, Denver Wildlife Research Center, Building 16, Federal Center, Denver, Colorado 80225 USA