Activity of Dimilin® (TH 6040) Against Coleoptera in Stored Wheat and Corn[1]

HARRISON E. MCGREGOR and KARL J. KRAMER[2]
U.S. Grain Marketing Research Center, Agric. Res. Serv., USDA, Manhattan, KS 66502

ABSTRACT

In laboratory tests, the insect growth inhibitor, Dimilin® (TH-6040, N-(4-chlorophenyl)-N'-(2,6-difluorobenzoyl) urea) applied at concentrations of 1 or 10 ppm to wheat or corn prevented progeny development of the rice weevil, *Sitophilus oryzae* (L.), granary weevil, *S. granarius* (L.), maize weevil, *S. zeamaiz* Motschulsky, lesser grain borer, *Rhyzopertha dominica* (F.), confused flour beetle, *Tribolium confusum* Jacquelin duVal, and sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.) Dimilin was less effective against the cigarette beetle, *Lasioderma serricorne* (F.). No progeny of the rice weevil, granary weevil, and lesser grain borer developed after preexposure of the adults to 10 ppm on wheat.

Dimilin® (TH-6040, N-(chlorophenyl-N'-(2,6-difluorobenzoyl) urea) is a growth inhibitor that apparently induces the degradation of newly synthesized chitin in insects (Wellinga et al. 1973, Post et al. 1974, Ishaaya and Casida 1974). Since the compound is active against a wide range of insects and has desirable levels of oral toxicity to mammals, we suspected that it might be useful as a protectant for stored grain. We therefore applied Dimilin on wheat and corn, and evaluated the activity against 7 species of Coleoptera including the rice weevil, *Sitophilus oryzae* (L.), granary weevil, *S. granarius* (L.), maize weevil, *S. zeamaiz* Motschulsky, lesser grain borer, *Rhyzopertha dominica* (F.), confused flour beetle, *Tribolium confusum* Jacquelin duVal, sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.), and cigarette beetle, *Lasioderma serricorne* (F.).

MATERIALS AND METHODS.—All insects were obtained from cultures maintained at the U.S. Grain Marketing Research Center; they had no prior history of exposure to insecticides. 'Chanute' wheat and 'Pioneer 3773' corn were obtained from commercial sources. Kernels were cleaned and tempered to a moisture of 12.5±0.5% as determined by a Motomco moisture meter.

Dimilin was obtained as a 25% WP and was stored at −10°C until used. Appropriate stock solutions were prepared in water to provide levels of 0.1, 1, 10, and 20 ppm insecticide (wt/wt) when applied to the grain. The kernels were treated as described previously (McGregor and Kramer 1975) and pint jars of treated grain (250 g) were infested initially with either 50 unsexed adults or larvae. For experiments in which immature rice and maize weevils were used, kernels containing the immature stages of the insects (1–2 wk old) were mixed with test grain before insecticide treatment. An additional test was made with the adult rice weevil using ground wheat pellets. An aqueous slurry of ground wheat (50% wt/wt) was passed through a 0.5 cm diam tube. After a 12-h drying period at room temperature, one cm pellets were cut away from the cylindrical strips. All experiments were conducted at 27°C and 60% RH and data are presented as the total number of progeny found in 4 replicate tests. After 3 wk, the original insects were removed and transferred to untreated grain to determine if their reproductive capacity was affected by Dimilin exposure. The progeny was counted after 9 wk in all tests. In those cases where the progeny levels were reduced significantly, the test samples also were examined after 6 months.

RESULTS.—Table 1 shows the activity of Dimilin applied to wheat or corn against 7 species of Coleoptera that commonly infest stored grain. A dose of either one or 10 ppm prevented the development of almost all progeny of the rice weevil, the granary weevil, the lesser grain borer, and the sawtoothed grain beetle (I, II). The compound was somewhat more effective on corn than on wheat against the weevils. Maize weevils, which were exposed as larvae inside the kernels, also had almost no progeny that developed (II). The F_1 population of the confused flour beetle was completely controlled by a dose of one ppm on either commodity. Only the cigarette beetle displayed a tolerance for Dimilin at the concentrations tested. At a 10 ppm application on corn, 30% of the F_1 population developed into adults. When Dimilin (one ppm) was uniformly mixed with pelleted ground wheat, no progeny of adult rice weevils matured, compared with a 96% reduction when whole kernels were treated at the same concentration (III).

Dimilin had good residual activity: almost no progeny of the rice weevil or confused flour beetle was produced when the respective adult insects were added to wheat kernels 6 and 3 mo, respectively, after chemical treatment (IV). Even when adult rice and granary weevils were placed in untreated wheat after their exposure to grain treated with 10 ppm Dimilin for 3 wk, they did not produce progeny that developed (V). This result can be attributed primarily to an effect on the reproductivity of the ♀ weevil and, to a lesser extent, the ♂ weevil. When 10 ppm Dimilin exposed ♀ rice weevils were mated with untreated males, a complete reduction in F_1 progeny occurred (916 adults emerged in the control experiment). X-ray analysis of the kernels showed that egg deposition had occurred, but no larvae were observed. The mating of exposed ♂ weevils and untreated females led to a reduction

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[2] Research Entomologist and Research Chemist, respectively. Mailing address: 1515 College Ave., Manhattan, KS 66502.

Table 1.—Activity of Dimilin against 7 species of stored grain beetles.

Insect	Method of exposure[a]	Control progeny	% reduction at ppm of			
			0.1	1.0	10.0	20.0
		WHEAT				
Rice weevil	I	6367	24	96	100	
	II	6677	5	>99	100	
	III	1310	89	100	100	
	IV	4993	18	95	>99	
	V	4213	7	64	100	
Granary weevil	I	3227	12	95	>99	
	V	196	30	95	98	
Maize weevil	II	2797	2	98	>99	100
Lesser grain borer	I	7543	93	99	>99	
	V	4000	35	87	>99	
Confused flour beetle	I	1382	17	100	100	
	II	1037	5	100	100	
	IV	2552	64	100	100	
	V	1296	0	0	0	
Sawtoothed grain beetle	I	3108	85	100	100	
	V	1030	0	16	9	
		CORN				
Rice weevil	I	1437	86	>99	>99	
Granary weevil	I	746	68	>99	100	
Maize weevil	II	1745	68	100	100	
Lesser grain borer	I	414	88	98	98	
Confused flour beetle	I	964	91	100	100	
Sawtoothed grain beetle	I	5683	91	>99	>99	
Cigarette beetle	I	5074	44	72	71	

[a] Experiments denoted as follows: I, adults placed on treated kernels; II, larvae on or in treated kernels; III, adults on pellets produced from ground treated kernels; IV, adults on kernels 6 (rice weevil) and 3 (confused flour beetle) months post-treatment; V, adults on untreated kernels after 3 wk pre-exposure to treated grain.

of only 65% in the F_1 progeny. The ability of the lesser grain borer to produce mature progeny also was diminished by preexposure of the adults to 10 ppm Dimilin treated grain (V). However, the confused flour beetle and sawtoothed grain beetle were not similarly affected.

DISCUSSION.—We have demonstrated that Dimilin is highly active as an inhibitor of the development of 6 of 7 coleopteran insects that commonly infest stored grain. Low doses of Dimilin protected wheat and corn for several months against progeny from both internal and external grain feeding insects when the chemical was homogeneously mixed with whole kernels. Since treated grain showed no appreciable damage from the infestation, any progeny most likely died in the embryonic or early larval stages. A dose of one ppm on corn was sufficient to control all test species but the cigarette beetle. The same dose applied to wheat controlled the lesser grain borer, confused flour beetle, and sawtoothed grain beetle, but a 10 times higher dose on wheat was required to control the 3 species of weevils tested.

Dimilin caused no mortality among the adults of any insect tested, but it did affect the fecundity of 3 species: the production of progeny by the rice weevil, granary weevil, and lesser grain borer was reduced 98% or more when the insects were preexposed to wheat treated with 10 ppm Dimilin. In the case of the rice weevil, this preexposure effect was most dramatic with the adult female where the chemical caused death of either the ovum, embryo or very young larva. It thus appears that Dimilin is active enough against coleopteran pests to be used as a grain protectant.

Since this manuscript was written, Carter [J. Stored Prod. Res. 11: 187–93 (1975)] has published similar results with some susceptible and resistant stored product beetles.

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