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Activity of Seven Chitin Synthesis Inhibitors Against Development of Stored Product Insects[1]

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ABSTRACT

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Seven chitin synthesis-inhibiting compounds were evaluated for activity against stored product insects in wheat. None of the compounds was acutely toxic to any species. N-[4-(4-nitrophenoxy)-3, 5-dichlorophenyl amino carbonyl]-2-chlorobenzamide with ID_{95} values of 0.1, 0.1, 0.3, 0.7, 0.8, 0.3, and 0.5 ppm, was most effective as a suppressor of development of the confused flour beetle, *Tribolium confusum* Jacquelin duVal, granary weevil, *Sitophilus granarius* (L.), lesser grain borer, *Rhyzopertha dominica* (F.), rice weevil, *S. oryzae* (L.), sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.), almond moth *Ephestia cautella* (Walker), and Indianmeal moth, *Plodia interpunctella* (Hübner), respectively. Other compounds were at least 10 times less effective.

Chitin synthesis inhibitors constitute a relatively new class of chemicals that are being developed as insecticides (Marx 1977, Vincent 1978). Some of the most active compounds have urea and halogenated benzamide moities as part of their structure. We evaluated the activity of 7 such chitin inhibitors, applied to wheat, against several species of stored product insects. The results are reported here.

Materials and Methods

All insects were obtained from cultures that were maintained at the U.S. Grain Marketing Research Laboratory and had no prior history of exposure to insecticides. The 'Chanute' wheat used in the tests was obtained from a commercial source, and kernels were cleaned and tempered to a moisture of 12.5% as determined by a Motomco® moisture meter (Motomco Inc., Clark, New Jersey). The chemicals (Fig. 1) evaluated were: I. N-[4-(4-nitrophenoxy)-3, 5- dichlorophenylaminocarbonyl]- 2- chlorobenzamide (98%, AI3-29346, Mobay Chemical. Corp.), II. N-[4-(trifluoromethoxy) phenylaminocarbonyl]-2-chlorobenzamide (98%, AI3-29368, Mobay Chemical Corp.), III. N-[5-(4-bromophenyl)-6-methyl-2-pyrazinyl]-aminocarbonyl-2,6-dichloro-benzamide (98%, AI3-29318, Lilly Research Labs), IV. N-[5-(α,α',α,α',α',α-hexafluro-3, 5-xylyl)-1, 3, 4-thiadiazol-2-yl[-2, 6-dimethoxybenzamide (98%, AI3-70756, Lilly Research Labs), V. 2-6-dimethoxy-N-[5-(α,α,α-trifluro-meta-tolyl)-1,3,4-thiadiazol-2-yl] benzamide (98% AI3-70757, Lilly Research Labs.), VI. N-[5-(p-chlorophenyl)-1,3,4-thiadiazol-2-yl]-2,6-dimethoxybenzamide (98%, AI3-70758, Lilly Research Labs.), VII. 2,6-dimethoxy-N-[5-(α,α,α-trifluoro-para-tolyl)-1,3,4-thiadiazol-2-yl] benzamide (98%, AI3-70759, Lilly Research Labs). Insects, 50 coleopteran adults or 50 lepidopteran eggs, were exposed to whole wheat (100 g) or ground wheat moth medium (100 g, Kinsinger (1975)) that had been treated with 0.1–100 ppm of test compound (McGregor and Kramer 1975, 1976). One hundred g of wheat or ground wheat media were treated by pipetting 5 ml of an acetone solution onto the diet and mixing thoroughly until the acetone had evaporated. The treated diet was allowed to equilibrate for at least 24–48 h before testing.

All experiments were conducted at 27°C and 60% RH. Toxicity to test insects was determined after 21 days of exposure. Inhibition of progeny development was determined after 9 wk of exposure. For tests with Lepidoptera, mortality percentages were calculated from the difference between the number of eggs added and adults that emerged. Values were corrected for mortality in untreated samples and the corrected mortality values were then used to establish the ppm per weight of diet required to suppress 95% of the control population by probit analysis (ID_{95}) (Finney 1952). For tests with Coleoptera, the number of original parent insects was subtracted from the total dead and live insects after 9 wk. When the progeny was reduced >10–20%, the samples were reexamined after 9 more wk.

Results and Discussion

None of the benzamide derivatives tested in this study were acutely toxic at levels tested to stored product beetles and moths. However, several suppressed development of progeny when applied to whole wheat or ground wheat media. The activity against coleopterans is reported in Table 1 and the number of progeny in untreated samples is given for comparison. Compounds I and II were extremely effective with ID_{95} values of 0.1–1.0 ppm. The other derivatives were less active: ID_{95} values ranged from 2–>100 ppm depending on the species and compound tested. In general, the confused flour beetle and lesser grain borer were the most susceptible species, and the rice weevil and granary weevil the least.

The activity of the compounds against lepidopteran insects is reported in Table 2. Moth species were rather tolerant of the benzamide compounds (ID_{95} 7–>100 ppm) except that development of progeny of the almond moth, *Ephestia cautella* (Walker) and Indianmeal moth, *Plodia interpunctella* (Hübner) were suppressed at 0.3 and 0.5 ppm compound I, respectively. The Angoumois grain moth, *Sitotroga cerealella* (Olivier) was more tolerant of I (ID_{95} ~10 ppm).

The most effective compound tested in this series was the nitrophenyldichlorophenoxybenzamide derivative I, which was inhibitory toward all species tested at <1

[1] This paper reports the results of research only. Mention of a pesticide does not constitute a recommendation by the USDA. Received for publication Oct. 11, 1978.

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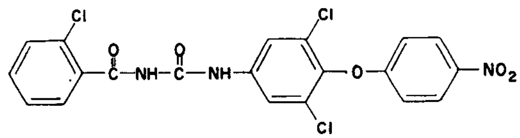

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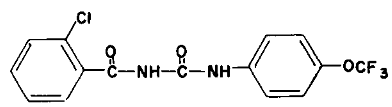

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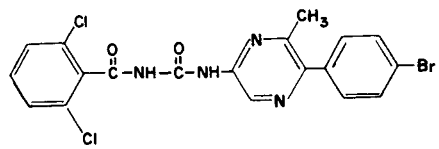

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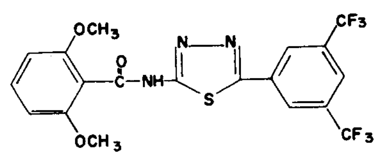

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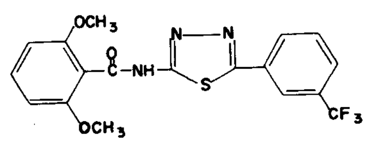

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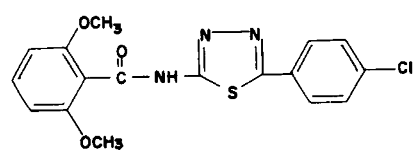

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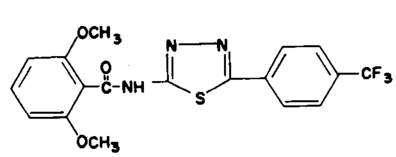

FIG. 1.—The structures of benzamide chitin inhibitors. See Materials and Methods for nomenclature.

ppm except for the Angoumois grain moth. Treated grain showed no appreciable damage from the infestations and it is likely that any progeny died in the ovum, embryonic, or early larval stages. The contraceptive activity of compound I against Coleoptera is about the same as that of the more well known benzamide derivative, diflubenzuron (McGregor and Kramer 1976). However, compound I is at least 10 times more active against Lepidoptera than diflubenzuron. The improved activity towards moth progeny indicates that chitin syn-

Table 1.—Activity of chitin inhibitors against development of coleopterans exposed from egg stage in wheat.

Species	Compound no.	No. F_1 insects in untreated sample[a]	ID_{95}[b]
Rice weevil	I	1110	0.7(0.6–0.9)
	II	1411	~1.0
	III	1125	15.5(10.6–27.6)
	IV	1902	>100
	V	208	>100
	VI	485	>100
	VII	385	>100
Confused flour beetle	I	260	~0.1
	II	243	~0.1
	III	156	5.1(4.1–6.8)
	IV	163	>100
	V	183	~5
	VI	174	11.9(9.1–15.2)
	VII	245	~5
Granary weevil	I	501	~0.1
	III	760	6.4(3.6–26.1)
	IV	851	>100
	V	102	>100
Lesser grain borer	I	935	~0.3
	III	882	2.3(2.1–2.6)
	IV	936	79.9(47.3–237.3)
	V	964	78.2(52.9–132.6)
Sawtoothed grain beetle	I	391	0.8(0.6–1.0)
	III	429	30.8(26.8–36.2)
	IV	338	>100
	V	389	24.7(19.0–35.4)

[a] Mean of 4 samples.
[b] 95% confidence limits given in parentheses.

Table 2.—Activity of chitin inhibitors against development of lepidopteran progeny in wheat or in wheat based medium.

Species	Compound no.	No. moths in untreated sample[a]	ID_{95}[b]
Indianmeal moth	I	48	0.5(0.5–0.6)
	II	43	>100
	III	40	14.0(10.0–23.6)
	IV	45	>100
	V	21	>100
	VI	42	>100
	VII	43	>100
Almond moth	I	34	0.3(0.2–0.3)
	III	41	7.0(4.6–13.2)
	IV	33	58.6(33.5–149.1)
	V	33	~50
Angoumois grain moth	I	31	~10
	III	37	16.0(8.2–44.7)
	IV	42	59.4(41.4–96.9)
	V	28	27.8(15.7–72.2)

[a] Fifty eggs added to 100 g of diet. Mean of 4 samples.
[b] 95% confidence limits given in parentheses.

thesis-inhibiting compounds can be effective as suppressors of development for the entire spectrum of insect pests encountered in stored products.

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REFERENCES CITED

Finney, D. J. 1952. Probit Analysis. 2nd ed. Cambridge University Press, London. 38 pp.

Kinsinger, R. A. 1975. Master's Thesis, Kansas State Univ. 75 pp.

Marx, J. L. 1977. Chitin synthesis inhibitors: new class of insecticides. Science 197: 1170–2.

McGregor, H. E., and K. J. Kramer. 1975. Activity of insect growth regulators, hydroprene and methoprene, on wheat and corn against several stored grain insects. J. Econ. Entomol. 68: 668–70.

1976. Activity of Dimilin (TH-6040) against Coleoptera in stored wheat and corn. Ibid. 69: 479–80.

Vincent, J. F. V. 1978. Cuticle under attack. Nature (London) 273: 339–40.