Dose Response of the Cowpea Curculio (Coleoptera: Curculionidae) From Different Regions of Georgia to Some Currently Used Pyrethroid Insecticides[1]

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ABSTRACT Adults of the cowpea curculio, *Chalcodermus aeneus* Boheman, obtained from infested peas in Attapulgus (SW), Midville (Central) and Tifton (So. Central), GA; were treated topically in the laboratory, with es-fenvalerate, cyfluthrin, cypermethrin and permethrin in 1988 to establish base-line data for the documentation of potential insecticidal resistance. A preliminary test was conducted in 1987, using permethrin, es-fenvalerate, cypermethrin, cyfluthrin and cyhalothrin on insects from Tifton. The log dose probit analysis indicated that in 1987 cyhalothrin was the most toxic of the materials tested. The 1988 test showed that es-fenvalerate was less toxic than the others and was also less toxic in Tifton, where pyrethroid insecticides have been used more extensively, than in Midville and Attapulgus.

KEY WORDS *Chalcodermus aeneus, Vigna unguiculata,* Probit, Pyrethroid insecticide, Lethal Concentration.

The cowpea curculio, *Chalcodermus aeneus* Boheman, is the most important insect pest problem in the production and marketing of the cowpea, *Vigna unguiculata* (L.) Walper in the southeastern United States. The most serious damage is caused by the larvae feeding on peas within the pods. Because larvae are not exposed to insecticides, control measures must be directed against adults.

The principal means of control has been the frequent application of insecticides. However, insecticides have lost their effectiveness throughout the years because this pest has developed resistance. Dupree and Beckam (1955) in Georgia stated that the most effective insecticides for the adult cowpea curculio were the organochlorines toxaphene, chlordane, aldrin, heptachlor and dieldrin. Suber et al. (1971) found that endosulfan, mevinphos, methyl parathion, parathion, methomyl, and carbofuran had good knockdown capability. Chalfant (1972, 1976) reported that four applications of toxaphene (the recommended insecticide at that time) during pod production protected the peas against attack, and ensured a marketable crop. However, during 1978-80, the curculio developed resistance to toxaphene (Chalfant 1985). As a result toxaphene was replaced by fenvalerate. However, because of a misinterpretation of the label this insecticide was incorrectly labelled

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and subsequently withdrawn for use on succulent cowpea in the U.S. Georgia experiments from 1981-1986 (Chalfant 1988) indicated that fenvalerate and permethrin were capable of insuring uninfested peas except under very heavy infestation. Subsequently, poor control with fenvalerate was reported by some growers. Currently permethrin is used under a special label exemption on cowpea in Georgia. However, since permethrin also is a pyrethroid insecticide, potential exists for developing resistance. Base-line mortality data on susceptible populations are required to identify initial resistance.

The following is a report on dosage mortality studies on the cowpea curculio using permethrin, es-fenvalerate and additional pyrethroid insecticides used on other crops in Georgia.

Materials and Methods

Adult cowpea curculios were obtained by collecting infested peas from three widely separated sites in Georgia; namely, Tifton, Midville and Attapulgus. The peas had not been treated with insecticides for control of curculio. Curculio larvae were allowed to emerge freely from the peas into 0.6 m square plastic tubs. Larvae were transferred to 40 × 60 × 6 cm deep plastic trays containing moist, sterile sand for pupation. The trays were covered with glass to maintain soil moisture and to prevent emerging adults from escaping. Emergence trays were held in a room at about 30° C. Adults were collected as they emerged and held for testing on fresh untreated peas in No. 8 brown paper bags. Insects were treated as they reached a sufficient number for a test.

Insecticides tested were technical formulations of es-fenvalerate, permethrin, cypermethrin, cyfluthrin and cyhalothrin. Es-fenvalerate and permethrin were tested on curculios from all three locations. Cyhalothrin was not tested on Tifton curculios in 1988 because of insufficient numbers. Each material was serially diluted with acetone. The number of doses varied with materials. There were four replications of 10 insects per dose. Insects were treated with a 1-ul droplet applied to the dorsal thoracic abdominal juncture. Acetone treatment was used as a check in each replication. Treated insects were held in 473 ml plastic cups containing fresh untreated cv 'Pinkeye Purple Hull' cowpea pods for food. Mortality data was recorded 72 hours after treatment. Data were analyzed using a probit program as described by Daum (1970). Significant differences ($P = 0.05$) between two insecticides were based on failure of the fiducial limits to overlap. An insect was considered dead when unable to stand upright or to assume a characteristic posture of feigned death when pressed with a sharp point on the ventral surface of the thorax (Suber et al. 1971).

Results and Discussion

The most toxic insecticide tested in 1987 was cyhalothrin followed by permethrin, cypermethrin, and cyfluthrin with almost equal toxicity (Table 1). Es-fenvalerate was significantly less toxic than the other materials. In 1988 higher concentrations were necessary to obtain responses than in 1987. For all insecticides except es-fenvalerate, there were no significant differences between regions. Es-fenvalerate was significantly less toxic to insects from Tifton than to those from Attapulgus and Midville. Permethrin was the most toxic to the cowpea curculio in all three

Table 1. Toxicity of insecticides to the cowpea curculio 72 hours after topical application, Tifton, GA. 1987.

Insecticides	LD_{50} (95% F. L.) ug/insect	LD_{90} (95% F. L.) ug/insect	Slope
Cyhalothrin	0.006 (0.005-0.007)	0.016 (0.013-0.022)	3.19
Cypermethrin	0.025 (0.021-0.028)	0.048 (0.040-0.064)	4.37
Cyfluthrin	0.026 (0.022-0.030)	0.055 (0.045-0.074)	3.94
Permethrin	0.027 (0.024-0.030)	0.042 (0.036-0.053)	6.62
Es-fenvalerate	0.11 (0.093-0.122)	0.196 (0.165-0.255)	4.83
Methyl Parathion	0.21 (0.180-0.244)	0.437 (0.360-0.578)	4.03

Table 2. Toxicity of insecticides to the cowpea curculio from three locations in Georgia 72 hours after topical application, 1988.

Insecticide Site	**LD_{50}** (95% F. L.) ug/insect	LD_{90} (95% F. L.) ug/insect	Slope
PERMETHRIN			
Attapulgus	0.033 (0.028-0.038)	0.068 (0.056-0.090)	3.99
Midville	0.040 (0.035-0.046)	0.071 (0.060-0.091)	5.19
Tifton	0.043 (0.037-0.049)	0.080 (0.067-0.100)	4.74
ES-FENVALERATE			
Attapulgus	0.130 (0.076-0.212)	0.348 (0.213-1.240)	3.00
Midville	0.157 (0.093-0.125)	0.578 (0.439-0.846)	2.66
Tifton	0.385 (0.294-0.493)	2.470 (1.760-3.930)	1.58
CYFLUTHRIN			
Attapulgus	0.047 (0.038-0.058)	0.199 (0.149-0.297)	2.05
Midville	0.056 (0.049-0.069)	0.220 (0.166-0.321)	2.17
CYPERMETHRIN			
Attapulgus	0.099 (0.081-0.120)	0.346 (0.264-0.502)	2.35
Midville	0.091 (0.073-0.122)	0.364 (0.274-0.537)	2.13

regions, followed by cyfluthrin, cypermethrin and es-fenvalerate. The LD_{50} of es-fenvalerate was 4 times higher than that of permethrin in Midville and Attapulgus and 9 times higher in Tifton. Its LD_{90} was 5 times higher than that of permethrin in Attapulgus, eight times more in Midville and 30 times more in Tifton. These differences corroborate failures of es-fenvalerate to control the cowpea curculio in the field. Although a lethal concentration was obtained for es-fenvalerate, it is suggested that the insect is developing resistance to it. For Tifton, the respective increases in LD_{50}s and LD_{90}s from 1987 to 1988 were 3.5 and 12.6 times. The slopes showed a marked decrease from 4.83 to 1.58, also suggesting resistance.

Resistance results from the selection of individuals in a population that survive pesticide applications (Georghiou 1985). The cowpea curculio has developed resistance to chlorinated hydrocarbons, organophosphates, and carbamates. The failure of fenvalerate to control the cowpea cuculio in the middle 1980's may be due to a cross-resistance from chlorinated hydrocarbons such as DDT and toxaphene. According to Miller et al. (1983), the pyrethroid insecticides share several properties with chlorinated hydrocarbons such as exerting their effects on the nerve and being more toxic at low temperature. These properties may confer cross-resistance to both classes of insecticides. Similar cross-resistance has been reported in mosquito (*Culex quiquefasciatus* Say) by Priester and Georghiou (1980). Also, moderate cross-resistance between DDT and pyrethroids has been demonstrated by Riskallah et al. (1983) in selected strains of *Spodoptera littoralis* (Boisd).

If resistance of the cowpea curculio to pyrethroids such as fenvalerate and esfenvalerate is actually cross-resistance from previously used chlorinated hydrocarbon insecticides, similar cross-resistance may rapidly occur between pyrethroid insecticides. In such a case, other pyrethroid insecticides such as permethrin, and potential substitutes such as cyfluthrin and cypermethrin may remain effective for only a short period of time, if used routinely. Suggested control measures should combine host plant resistance with alternation of insecticides, reduced number of applications, and appropriate cultural methods to prolong the effectiveness of the insecticides.

References Cited

Chalfant, R. B. 1972. Cowpea curculio: control in southern Georgia J. Econ. Entomol. 66: 727-729.

Chalfant, R. B. 1976. Chemical control of insect pests of southern pea in Georgia. Univ. Res. Bull. 179. 31 pp.

Chalfant, R. B. 1985. Entomological research on cowpea pests in the USA, pp 265-271. *In:* Singh, S. A. and K. O. Rachie, eds, Cowpea Research, Production and Utilization. John Wiley & Sons, Chichester, NY, Brisbane, Toronto, Singapore. 460 pp.

Chalfant, R. B. 1988. Cowpea curculio, *Chalcodermus aeneus* Boheman (Coleoptera: Curculionidae); insecticidal control on the southern pea in Georgia, 1980-1986. App. Agric. Res. 3: 8-11.

Daum, R. J. 1970. Revision of two computer programs for probit analysis. Bull. Entomol. Soc. Am. 16(1): 10-15.

Dupree, M. and C. M. Beckham. 1955. The cowpea curculio, a pest of southern peas. Ga. Agric. Exp. Stn. Bull. N. S. 6, 32 pp.

Georghiou, G. P. 1985. The magnitude of the resistance problem, pp. 14-43. *In:* Committee on Strategies for the Management of Pesticide Resistant Pest Populations, eds, Pesticide Resistance. National Academy Press, Washington, D. C. 471 pp.

Miller, T. A., V. L. Solyado, and S. N. Irving. 1983. The kdr factor in pyrethroid resistance, pp 353-364. *In:* Georghiou, G. P. and T. Saito, eds, Pest Resistance to Pesticides. Plenum Press, NY. 809 pp.

Priester, T. M. and G. P. Georghiou. 1980. Cross-resistance spectrum in pyrethroid resistant *Culex quinquefasciatus.* Pesticide Sci. 11: 617-624.

Riskallah, M. R., S. F. Abd-Elgharfar, M. R. Abo-Elghar, and M. E. Nassar. 1983. Development of resistance and cross-resistance in fenvalerate and deltamethrin selected strains of *Spodoptera littoralis* (Boisd.). Pesticide Sci. 14: 508-512.

Suber, E. F., R. B. Chalfant, and T. D. Canerday. 1971. Toxicity of insecticides to the cowpea curculio in the laboratory. J. Econ. Entomol. 64: 1080-1081.