COMPARATIVE TOXICITIES OF SYNTHETIC PYRETHROIDS TO THE FALL ARMYWORM, *SPODOPTERA FRUGIPERDA*

GINGER L. GIST[1] AND CHARLES D. PLESS
Department of Entomology and Plant Pathology
University of Tennessee
Knoxville, TN 37996-4500 USA

ABSTRACT

Nine synthetic pyrethroids were tested in the laboratory for toxicity to third and sixth instar fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae). LD_{50} values for 3rd instar FAW ranged from 0.0041 μg/insect (permethrin [FMC]) to 0.1558 μg/insect (Ammo®). All pyrethroids were more toxic than diazinon. LD_{50} values for 6th instar ranged from 0.213 μg/insect (permethrin [FMC]) to 5.841 μg/insect (Ammo®). Ammo® was the only pyrethroid less toxic than diazinon to 6th instar.

RESUMEN

Se evaluaron en el laboratorio nueve pyrethroids para toxicidad hacia el tercer y sexto estadio del cogollero, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae). Valores de LD_{50} para el 3er. estadio del cogollero varió de 0.0041 μg/insecto (permethrin (FMC)) a 0.1558 μg/insecto (Ammo®). Todos los pyrethroids fueron más tóxicos que diazinon. Los valores de LD_{50} para el 6to. estadio varió de 0.213 μg/insecto (permethrin [FMC], a 5.841 μg/insecto (Ammo®). Ammo® fue el único pyrethroid menos toxico que diazinon hacia el 6to. estadio.

The synthetic pyrethroids, first described in 1973, have been cited for their potential as agricultural pest control agents (Breese 1977, Elliott et al. 1978, Hall 1979, Harris and Svec 1976, Schmidt et al. 1976). The degree of control of the fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith), one of the most important insect pests in the southeast United States, (Fuxa 1982, Mitchell 1979), with the synthetic pyrethroids has varied. Bass (1978) reported poor control in peanuts with Ambush® and Pydrin® and unacceptable control on grain sorghum from Pounce®, Pydrin®, and FMC 45498. However, Wood et al. (1981) found permethrin to be more toxic than methyl parathion, trichlorfon, or carbaryl to FAW larvae reared on various diets.

The purpose of this study was to evaluate contact toxicities of 9 synthetic pyrethroids to a laboratory strain of FAW.

MATERIALS AND METHODS

Larvae used in contact toxicity tests were from a laboratory reared

[1]Current Address: Department of Environmental Health, Box 22960 A, East Tennessee State University, Johnson City, TN 37614-0002.

colony established in February 1982 with pupae obtained from the Southern Grain Insects Research Laboratory in Tifton, Georgia. The insects were reared on artificial diet (Bio-Serv Corn Earworm Rearing Media, Bio-Mix #9394) according to a procedure modified from Perkins (1979).

One liter of insecticide-acetone (wt/vol) solution was applied to the dorsal thoracic region of 3rd or 6th instars with a syringe microburet. Larvae were placed into individual 5 cm diam petri dishes and allowed to feed on artificial diet. Larvae were maintained in environmental chambers at 27° ± 2°C, 14:10 L:D, and 60-70% RH. Mortality, determined by failure to respond to probing, was recorded at 24 h.

Preliminary dosages of insecticides were used to establish mortality ranges. Dosages-mortality regression lines, obtained by probit analysis (Finney 1964), provided LD_{50} values, confidence intervals, LD_{90} values, and slopes for each insecticide for 5-10 dose levels using a minimum of 30 larvae/dose. A toxicity index (Sun 1950) was used to compare the toxicity of each synthetic pyrethroid with that of diazinon, an organophosphate used as a standard.

The synthetic pyrethroids were technical formulations of permethrin and cypermethrin (ICI Americas, Inc.); permethrin, cypermethrin, Pounce®, and Ammo® (FMC Agricultural Chemical Group); Pydrin® (Shell Development Co.); Mavrik® (Zoecon Corp.); and Pay-Off® (American Cyanamid Co.).

Results and Discussion

The pyrethroids were 3 to 120 times more toxic than diazinon to 3rd instar (Table 1). LD_{50} values ranged from 0.1558 µg/insect (Ammo®) to 0.0041 µg/insect (permethrin [FMC]), representing a 38-fold decrease in concentration. Relatively flat regression lines for Pydrin®, cypermethrin (ICI), and Ammo® suggest heterogenous responses (Hoskins and Gordan 1956), indicating a possible tolerance to those insecticides by portions of the population.

The synthetic pyrethroids, with the exception of Ammo®, were also effective contact insecticides to 6th instar FAW (Table 2). LD_{50} values ranged from 5.841 µg/insect (Ammo®) to 0.213 µg/insect (permethrin

TABLE 1. Comparative toxicities of nine synthetic pyrethroids to laboratory-reared 3rd instar fall armyworm.

Compound	LD_{50} µg/insect	LD_{50} C.L.	LD_{90} µg/insect	slope	Toxicity index
permethrin (FMC)	0.0041	0.0036-0.0045	0.0102	3.82	11,968
permethrin (ICI)	0.0067	0.0062-0.0071	0.0110	5.67	7,324
Pounce®	0.0271	0.0178-0.0354	0.0590	3.10	1,811
cypermethrin (FMC)	0.0307	0.0104-0.0407	0.1053	2.73	1,598
Pay-Off®	0.0407	0.0275-0.0696	0.1215	2.70	1,207
Mavrik®	0.0487	0.0309-0.0507	0.0776	4.74	1,008
Pydrin®	0.1277	0.0712-0.1701	0.5808	1.95	384
cypermethrin (ICI)	0.1327	0.1301-0.2104	0.9445	1.69	370
Ammo®	0.1558	0.1390-0.2291	0.9339	1.71	315
diazinon	0.4907	0.4883-0.5158	1.0321	2.87	100

TABLE 2. COMPARATIVE TOXICITIES OF NINE SYNTHETIC PYRETHROIDS TO LABORATORY REARED 6TH INSTAR FALL ARMYWORM.

	LD_{50}		LD_{90}		Toxicity
Compound	μg/insect	C.L.	μg/insect	slope	index
permethrin (FMC)	0.213	0.200-0.372	0.561	2.49	1,820
cypermethrin (FMC)	0.250	0.187-0.687	0.788	2.87	1,550
Pay-Off®	0.306	0.190-0.385	0.978	2.78	1,267
permethrin (ICI)	0.662	0.649-0.706	1.122	5.23	585
cypermethrin (ICI)	0.684	0.501-0.882	1.289	5.50	567
Pydrin®	0.813	0.524-1.214	1.574	5.26	477
Mavrik®	1.456	0.340-1.657	7.435	2.83	266
Pounce®	3.471	2.044-4.202	7.100	4.20	112
Ammo®	5.841	5.204-6.582	11.847	3.91	66
diazinon	3.876	3.477-4.000	10.980	4.63	100

[FMC]), a 27-fold decrease in concentration. The pyrethroids, except Pounce® and Ammo® were from 2.5 to 18 times more toxic than diazinon to 6th instar. Pounce® had approximately the same toxicity as diazinon, and Ammo® was approximately 0.67 as toxic as diazinon. All pyrethroids had relatively steep regression lines indicating a homogenous response. This is a characteristic for insect populations that have not been exposed to any significant chemical selection pressure which allows a buildup of tolerance to the toxicant (Hoskins 1960).

Third instar larvae were more susceptible to the pyrethroids than were 6th instar. Differences in susceptibility ranged from 5X (cypermethrin [ICI]) to 128X (Pounce®). Diazinon was ca. 8X more toxic to 3rd instar than to 6th instar.

Within 10 min after treatment with pyrethroids at any concentration larvae displayed symptoms of pyrethroid poisoning (Ford et al. 1977), including initial hyperactivity, fluid loss due to regurgitation and eversion of the rectum, loss of coordination, knockdown leading to paralysis, and death. These reactions to poisoning may provide additional protection to plants by dislodging surviving insects and/or exposing them to increased predation. Water loss may also contribute to mortality, especially in hot summer weather.

McDonald (1979) found pyrethroids in general to be more toxic than organophosphates to the army cutworm. In this study, the pyrethroids were found to be more toxic than diazinon to FAW larvae even though the modes of action of the two insecticide classes are thought to be similar. Synthetic pyrethroids are better contact poisons than oral poisons (McDonald 1976), possibly because of their feeding deterrent properties (Gist and Pless 1985) which cause the insect to avoid ingesting the toxin.

The difference in toxicities of the pyrethroids in the laboratory vs the field can be partially explained by the absence of selective pressure in the laboratory population, demonstrated by the relatively steep dosage-mortality lines. Variation in toxicities to FAW has been explained on the basis of insect resistance (Farnham and Sawicki 1976), tolerance, cross resistance (Crowder et al. 1979, Twine and Reynolds 1980), and differences in the host crop (Wood et al. 1981). Because susceptibility of FAW to insecticides varies with the crop upon which they are feeding (Wood et al. 1981), additional field evaluations are needed to correlate efficacy in the field with that in the laboratory.

REFERENCES CITED

BASS, M. H. 1978. Fall armyworm: Evaluation of insecticides for control. Agric. Exp. Stn. Auburn Univ. Leaflet 93: 7.

BREESE, M. H. 1977. The potential for pyrethroids as agricultural, veterinary, and industrial insecticides. Pestic. Sci. 8: 264-269.

CROWDER, L. A., M. S. TOLEFSON, AND T. F. WATSON. 1979. Dosage-mortality studies of synthetic pyrethroids and methyl parathion on the tobacco budworm in Central Arizona. J. Econ. Entomol. 72: 1-3.

ELLIOT, M., N. F. JANES, AND C. POTTER. 1978. The future of pyrethroids in insect control. Annu. Rev. Entomol. 23: 443-469.

FARNHAM, A. W., AND R. W. SAWICKI. 1976. Development of resistance to pyrethroids in insects resistant to other insecticides. Pestic. Sci. 7: 278-282.

FINNEY, D. J. 1964. Probit analysis. Cambridge Univ. Press. P. 318.

FORD, M. G., R. C. REAY, D. PERT, P. E. ELLIS, AND L. J. MCVEIGH. 1977. Toxicity of pyrethroids to larvae of the Egyptian cotton leafworm, *Spodoptera littoralis* (Boisd.). I. Relative toxicities and knockdown activities of benzyl, and 5-benxyl-3-furylmethyl, cyclopropanecarboxylates. Pestic. Sci. 8: 203-210.

GIST, G. L. AND C. D. PLESS. 1985. Feeding deterrent effects of synthetic pyrethroids on the fall armyworm, *Spodoptera frugiperda*. Florida Entomol. (In press).

HALL, F. R. 1979. Effects of synthetic pyrethroids on major insect and mite pests of apple. J. Econ. Entomol. 72: 441-446.

HARRIS, C. R. AND H. J. SVEC. 1976. Susceptibility of the Colorado potato beetle in Ontario to insecticides. Ibid. 69: 625-629.

HOSKINS, W. M. 1960. Use of the dosage-mortality curve in quantitative estimation of insecticide resistance. Misc. Publ. Entomol. Soc. Am. 2: 85-91.

MCDONALD, S. 1976. Evaluation of several new insecticides for the control of the Colorado potato beetle and the status of DDT resistance in southern Alberta. J. Econ. Entomol. 69: 659-664.

MITCHELL, E. R. 1979. Preface to fall armyworm symposium. Florida Entomol. 62: 81.

PERKINS, W. D. 1979. Laboratory rearing of the fall armyworm. Ibid. 62: 87-91.

SCHMIDT, C. D., J. J. MATTER, J. H. MEUER, R. E. REEVES, AND B. K. SHELLEY. 1976. Evaluation of a synthetic pyrethroid for control of stable flies and barn flies on cattle. J. Econ. Entomol. 69: 484-486.

SUN, Y. P. 1950. Toxicity index—an improved method of comparing the relativity toxicity of insecticides. Ibid. 43: 45-53.

TWINE, P. H. AND T. H. REYNOLDS. 1980. Relative susceptibility and resistance of the tobacco budworm to methyl parathion and synthetic pyrethroids in Southern California. Ibid. 72: 239-242.

WOOD, K. A., B. H. WILSON, AND J. B. GRAVES. 1981. Influence of host plant on the susceptibility of the fall armyworm to insecticides. Ibid. 74: 96-98.