SYNERGISTIC ACTIVITY OF PIPERONYL BUTOXIDE WITH NINE SYNTHETIC PYRETHROIDS AGAINST THE FALL ARMYWORM, *SPODOPTERA FRUGIPERDA*

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ABSTRACT

Nine synthetic pyrethroids were evaluated in the laboratory for synergistic activity with piperonyl butoxide (1:8) when used on fall armyworm, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae). The cypermethrins (FMC Agricultural Chemical Group and ICI Americas, Inc.) were the only pyrethroids to have significant (Synergistic Ratio = 3.531 and 6.328 respectively) synergistic activity to eggs. Cypermethrin (FMC) (SR = 3.0700) and Ammo® (SR = 9.1111) were significantly synergized for 3rd instar. Ammo® (SR = 8.641) was significantly synergized for 6th instar.

RESUMEN

Se evaluaron en el laboratorio nueve pyrethroidos sintéticos para actividades sinergéticas con piperonyl butoxide (1:8) cuando se usaron contra el cogollos, *Sodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae). Los cypermethrins (FMC Agricultural Chemical Group and ICI Americas, Inc.) eran los únicos pyrethroidos que tuvieron una significante actividad sinergética hacia los huevos (una proporción sinergética = 3.531 y 6.328 respectivamente). Cypermethrin (FMC) (Reacción Sinergética = 3.0700) y Ammo® (Reacción Sinergética = 9.1111) fue significamente sinergético hacia el 3er. estadio. Ammo® (Reacción Sinergética = 8.641) fue significamente sinergético hacia el 6to. estadio.

Insecticidal synergism can be defined as increased activity (of an insecticide) resulting from the effect of one chemical on another. The first commercial synergist was introduced in 1940 to increase the effectiveness of the botanical insecticide, pyrethrum. Since that time it has been well established that synergists increase the effectiveness of pyrethroidos by reducing their rate of metabolism in insects (Casida 1970, Jao and Casida 1974a,b, Yamamoto 1973).

The optimal synergist varies with the insect species and pyrethroid (Jao and Casida 1974a) as well as the stage of the insect's development, Yu (1983) pointed out that activities of various detoxifying enzymes fluctuate during the life stages of insects, thus low activity of these enzymes would indicate a susceptible period and vice versa. Piperonyl butoxide (PB), an oxidase inhibitor is the most commonly used synergist, although reports of

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The purpose of this study was to evaluate the synergistic activity of piperonyl butoxide with 9 synthetic pyrethroids to a laboratory strain of fall armyworm (FAW), Spodoptera frugiperda (J. E. Smith).

**MATERIALS AND METHODS**

Procedures for ovicidal tests have been previously reported (Gist and Pless 1985b). Briefly, egg masses were treated by dipping them into acetone solutions of insecticide: PB. Each treatment was applied to 75-100 eggs and replicated 3 times. Eggs which hatched were counted daily for 7 days.

Larvae were reared and treated according to procedures detailed previously (Gist and Pless 1985a). Third and 6th instars were treated with 1 ml applications of insecticide: PB. Each treatment was applied to 3 replicates of 10 larvae/instar. Mortality was determined after 24h.

Insecticide-acetone (wt/vol):synergist-acetone (wt/vol) (1:8) solutions were tested. Preliminary dosages of insecticide:synergist solutions were used to establish mortality ranges. Dosage-mortality regression lines, obtained by probit analysis (Finney 1964) provided LC$_{50}$ or LD$_{50}$ values for each insecticide:synergist solution for 5-10 dose levels. Synergistic ratios (LC$_{50}$ or LD$_{50}$ of pyrethroid alone/LC$_{50}$ or LD$_{50}$ of pyrethroid + synergist) were established with LC$_{50}$ or LD$_{50}$ values from Gist and Pless (1985a,b). The Mann-Whitney U Test was used to determine significance of synergised vs. nonsynergised comparisons.

Synthetic pyrethroids used in this study 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.). The synergist used was Prentox PBO 8® (91.3% technical piperonyl butoxide) (Prentiss Drug and Chemical Co., Inc.).

**RESULTS AND DISCUSSION**

The pyrethroids were not readily synergised by PB when applied to FAW (Table 1). The only pyrethroids to have synergistic activity on eggs were cypermethrin (FMC) (SR $\equiv$ 3.5) and cypermethrin (ICI) (SR $\equiv$ 6.3). Cypermethrin (FMC) (SR $\equiv$ 3.1) and Ammo® (SR $\equiv$ 9.1) had synergistic activity on 3rd instar. Ammo® (SR $\equiv$ 8.6) was the only pyrethroid to have synergistic activity on 6th instar. All of the above synergistic ratios are in the low to slightly moderate range of synergism.

For metabolic research, synergism is usually investigated by applying a synergist followed by an application of the active insecticide (Elliot and Janes 1978). This method would not be practical in field situations; therefore, it was not used in this study.

The cypermethrins (ICI, FMC, and Ammo®) were the only pyrethroids to show synergistic activity on FAW. In each case, synergism decreased with increased age of the insects. Chang and Jordan (1982) showed that permethrin penetrated into Wiseana cervinata larvae faster than cypermethrin. Casida (1970) pointed out that most well-known synergists, including PB,
<table>
<thead>
<tr>
<th>Compound</th>
<th>Eggs (LC&lt;sub&gt;50&lt;/sub&gt;)&lt;sup&gt;1&lt;/sup&gt;</th>
<th>3rd instar (LD&lt;sub&gt;50&lt;/sub&gt;)&lt;sup&gt;2&lt;/sup&gt;</th>
<th>6th instar (LD&lt;sub&gt;50&lt;/sub&gt;)&lt;sup&gt;2&lt;/sup&gt;</th>
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<tr>
<td></td>
<td>(A) (B) SR&lt;sup&gt;3&lt;/sup&gt;</td>
<td>(A) (B) SR&lt;sup&gt;3&lt;/sup&gt;</td>
<td>(A) (B) SR&lt;sup&gt;3&lt;/sup&gt;</td>
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<tr>
<td>Pay-Off®</td>
<td>0.320 0.360 0.890 NS</td>
<td>0.0407 0.0153 2.6601 NS</td>
<td>0.306 0.524 0.584 NS</td>
</tr>
<tr>
<td>Mavrik®</td>
<td>1.164 0.866 1.344 NS</td>
<td>0.0487 0.0189 2.5757 NS</td>
<td>1.456 1.121 1.299 NS</td>
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<tr>
<td>permethrin (FMC)</td>
<td>1.378 2.198 0.627 NS</td>
<td>0.0041 0.0019 2.1579 NS</td>
<td>0.213 0.330 0.646 NS</td>
</tr>
<tr>
<td>permethrin (ICI)</td>
<td>1.572 0.813 1.934 NS</td>
<td>0.0067 0.0042 1.5952 NS</td>
<td>0.662 0.781 0.848 NS</td>
</tr>
<tr>
<td>cypermethrin (FMC)</td>
<td>1.557 0.441 3.531 *</td>
<td>0.0307 0.0100 3.0700 *</td>
<td>0.250 0.341 0.748 NS</td>
</tr>
<tr>
<td>cypermethrin (ICI)</td>
<td>2.006 0.317 6.328 *</td>
<td>0.1327 0.1155 1.0489 NS</td>
<td>0.684 0.431 1.057 NS</td>
</tr>
<tr>
<td>Pounce®</td>
<td>4.000 3.754 1.066 NS</td>
<td>0.0071 0.0098 2.9140 NS</td>
<td>3.471 4.246 0.817 NS</td>
</tr>
<tr>
<td>Ammo®</td>
<td>7.375 3.875 1.908 NS</td>
<td>0.1558 0.0171 9.1111 *</td>
<td>5.841 0.676 8.641 *</td>
</tr>
<tr>
<td>Pydrin®</td>
<td>12.230 15.405 0.794 NS</td>
<td>0.1277 0.1055 1.1770 NS</td>
<td>0.813 0.591 1.376 NS</td>
</tr>
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<sup>1</sup>LC<sub>50</sub> = Concentration to kill 50% of individuals tested (ppm).

<sup>2</sup>LD<sub>50</sub> = Dosage to kill 50% of individuals tested (μg/insect).

<sup>3</sup>SR = Synergistic ratio = (A)/(B).

*Significantly greater than 1.0 at p ≤ 0.05; NS, not significantly greater than 1.0.
are fat-soluble and therefore favor penetration through the insect cuticle. Pepper and Hastings (1943) and Gast (1961) found that, during larval development, the insect cuticle varied in its composition. For example, lipid content causes changes in insecticide susceptibility. Thus, it is possible that the small residual factor of synergism shown by cypermethrin may be explained by physical effects of the large dose of lipophilic synergist on penetration as well as the increased penetration of the pyrethroid itself. The decrease in insecticide susceptibility with increased larval age of FAW could also be due to an increase in insecticide metabolizing enzymes in older larvae (Yu 1983).

Yu (1982) indicated that an increase in detoxifying enzymes due to host plant induction results in a protective effect against various insecticides, including pyrethroids, in FAW. This is supported by Wood et al. (1981) who showed that FAW susceptibility to insecticides, including permethrin, varied with the host plant. In view of this, addition of a synergist to pyrethroids to increase their insecticidal potency and cost efficiency is tempting; however, concomitant alterations in mammalian toxicity may shift compounds otherwise considered safe into a hazardous category (Casida and Ruzo 1980).

REFERENCES


———. 1983. Age variation in insecticide susceptibility and detoxification capacity of the fall armyworm (Lepidoptera: Noctuidae) larvae. J. Econ. Entomol. 76: 219-222.

CAULOTOPS DISTANTI (MIRIDAE: HETEROPTERA), A POTENTIAL YUCCA PEST NEWLY DISCOVERED IN THE UNITED STATES

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ABSTRACT

The plant bug Caulotops distanti (Reuter) is reported for the first time in the United States based on specimens collected in two Florida nurseries damaging potted cuttings of Yucca elephantipes Regel (Agavaceae). Because some of the potted plant material infested with C. distanti has been sold, this potential Yucca pest is considered at least temporarily established in the United States. Caulotops distanti was imported from Costa Rica, probably as eggs inserted in the stems of its host. A diagnosis and key are provided to help separate C. distanti from other U. S. species of Caulotops and the morphologically similar Halticotoma valida Townsend.

RESUMEN

Se reporta por primera vez en los Estado Unidos a Caulotops distanti (Reuter), basado en muestras colectadas en dos viveros, dañando plantas de Yucca elephantipes Regel (Agavaceae) sembradas en jarrones. Puesto que algunas de estas plantas infestadas con C. distanti han sido vendidas, esta posible plaga de Yucca es por lo menos temporalmente considerada establecida en los Estados Unidos. Caulotops distanti fue importada de Costa Rica, posiblemente como huevos insertados en los tallos del hospedero. Se provee un diagnóstico y una clava para ayudar a separar a C. distanti de otras especies de Caulotops de los Estados Unidos y del morfológicamente similar Halticotoma valida Townsend.

The plant bug Caulotops distanti (Reuter) is here reported for the first time in the United States based on specimens submitted to the Systematic Entomology Laboratory, IIBIII, Agricultural Research Service, USDA, Washington, D.C. In this paper I outline the steps leading to the discovery of this mirid, present comments on its economic potential, and provide a diagnosis and key to the U. S. species of Caulotops.