RELATIONSHIP OF FALL ARMYWORM (LEPIDOPTERA: NOCTUIDAE) FROM FLORIDA, HONDURAS, JAMAICA, AND MISSISSIPPI: SUSCEPTIBILITY TO INSECTICIDES WITH REFERENCE TO MIGRATION

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ABSTRACT

Fall armyworm (FAW), Spodoptera frugiperda (J. E. Smith), cultures established in 1985 from larvae collected on corn in Florida and Jamaica and on sorghum in Mississippi and Honduras were tested in the laboratory for susceptibility to carbaryl, permethrin, methomyl, chlorpyrifos, and methyl parathion using leaves from sorghum plants sprayed with insecticide in the field. Methomyl and chlorpyrifos were effective (85% mortality) against 3rd instar FAW larvae from Jamaica and Mississippi whereas mortality of similar larval stages from Honduras was 50%. The Florida culture appeared to be about equally tolerant to all the test insecticides. Carbaryl, methyl parathion and permethrin were ineffective against 3rd instar larvae from all test areas. However, preliminary field tests indicated that 1st instar Honduran FAW larvae are susceptible to methyl parathion. Also, materials shown to be ineffective against 3rd instar larvae in the whorl were effective on FAW when applied to the sorghum seed head in a separate study. Susceptibility responses to insecticides indicate that the FAW population from Mississippi was more similar to test populations from Jamaica and Honduras, than to the test population from Florida, suggesting that the FAW source from Florida may not be the source of insects invading Mississippi.

RESUMEN

Poblaciones del gusano cogollero, Spodoptera frugiperda (J. E. Smith), establecidas en 1985 de larvas colectadas en maíz en la Florida y Jamaica, y en sorgo en Mississippi y Honduras, se probaron en el laboratorio para determinar su susceptibilidad al carbaryl, permethrin, methomyl, chlorpyrifos, y metilo de paración, usando hojas de plantas de sorgo rocías con insecticidas en el campo. Methomyl y chlorpyrifos fueron efectivos (85% de mortalidad) contra el 3er. estadio de larvas del gusano cogollero de Jamaica y Mississippi, mientras que la mortalidad de etapas larvales similares de Honduras fue un 50%. La población de la Florida también parece ser tolerante a todos los insecticidas probados. Carbaryl, metilo de paración, y permethrin fueron inefectivos contra el 3er. estadio de larvas de todas las áreas de prueba. Sin embargo, pruebas preliminares en el campo indicaron que el primer estadio de larvas del gusano cogollero
de Honduras son susceptibles al metilo de paratión. Materiales demostrados ser inefec-
tivos contra el 3er. estadio de larvas en el vertículo de plantas, fue efectivo contra el
gusano cogollero cuando se aplicó a semillas en la planta del sorgo. Reacción de suscep-
tibilidad a insecticidas indicaron que la población de gusanos cogolleros de Mississippi
fue más similar a las poblaciones de Jamaica y de Honduras, que a la población de la
Florida, lo que sugiere que el origen de gusanos cogolleros de la Florida tal vez no sea
el origen de insectos que invaden a Mississippi.

The polyphagous fall armyworm (FAW), Spodoptera frugiperda (J. E. Smith), is a
sporadic and occasionally severe pest of pasture and row crops in many areas in the
Western Hemisphere (Sparks 1979, Andrews 1980). Where this insect is a pest, insecti-
cides have been used successfully to control larval infestations. An update on chemical
control of S. frugiperda was presented in a recent review by Pitre (1986). Although
several insecticides provide effective control of FAW, published data reveal that insecti-
cide resistant FAW populations are present in the southeastern United States. How-
ever, data from the mid-south and west of the Mississippi River have not revealed high
levels of FAW resistance to insecticides (Young 1979a). Insecticide resistance in FAW
in Central and South America also has been reported (Young 1979a, Arevalo 1980,
Waquil et al. 1982).

The migration of FAW into the United States each year from southern latitudes
(Luginbill 1928, Mitchell 1979, Sparks 1979, Hogg et al. 1982), the development of
insecticide resistance, and the possible existence of host strains and possibly sibling
species (Pashley et al. 1985, Pashley 1986) present the need to determine the relation-
ship of FAW immigration to insecticide control. Fall armyworms from different sources
develop differently on various hosts (Pantoja et al. 1987), and respond differently to
various isolates of NPV (Fuxa 1987) and to different insecticides (Young 1979b). These
differing responses to environmental and biological factors support the need to under-
stand the relationships of geographic location of FAW and their potential as immigrating
infestation sources from the Caribbean and Central and South America. Knowledge of
the origin of immigrant FAW and their susceptibility to insecticides is important in
developing pest management strategies in the United States.

In the present study, FAW from Florida, Honduras, Jamaica and Mississippi were
cultured and tested for susceptibility to several insecticides in order to establish ex-
pected levels of control and possible relationships of the origin of FAW in reference to
insect migration and control in the United States.

MATERIALS AND METHODS

Fall armyworm larvae (n = 80-100) were collected from corn, Zea mays L., in
southern Florida near Homestead and on the north coast of Jamaica near Ocho Rios,
and from sorghum, Sorghum bicolor (L.) Moench., at Choluteca, Honduras and Starkville, Mississippi. The insects were reared on artificial diet (Bio-Mix 9782, Bio-
Serv., Inc.) in the laboratory for 2 to 4 generations before insecticide susceptibility tests
were conducted. The colonies were kept separately and rearing procedures prevented
mixing of FAW from different regions.

Sorghum, (DeKalb 42Y), in small replicated field plots (2 rows, each 15.2 m long and
76.7 cm apart) in the late whorl stage was uniformly sprayed with one of five insecticides
at recommended rates for control of FAW; plants in rows not sprayed were used as the
untreated control. The insecticide was applied in 190 liters water per hectare using a
hand-held compressed air sprayer fitted with a cone nozzle at 30 psi with the spray
directed over the whorl of the plants. Temperature at application time was 21°C and the sky was sunny with little cloud cover.

Sorghum leaves treated with insecticide were clipped from the plants in the treatment plots less than 0.5 h after the spray had dried on the leaf surface. Foliage treated with each insecticide was kept separate and placed between moist paper towels for a brief period (ca. 20 min.) during transport to the laboratory in an insulated box. Equal amounts of treated or untreated foliage from the plants were placed into ventilated plastic cups, arranged in a randomized complete block design with four replications per treatment (= colony x insecticide combination) and four subsamples (=4 cups) for each treatment within each replication. Moist paper was placed in the bottom of each cup to increase humidity within the container. Five 3rd instar larvae (ca. 1.27 cm long) were placed into each cup and held in a cabinet at 26.7 + 2°C and 60% RH. Mortality was recorded after 24 h exposure to the foliage. Cannibalism was not a factor in this experiment.

Percent mortality adjusted by Abbott’s formula (Abbott 1925), was calculated for individual treatments and the mortality data for each insecticide across colonies and for insecticides within colonies were analyzed using analysis of variance. Treatment means were separated by Duncan’s multiple range test (Duncan 1955).

RESULTS AND DISCUSSION

Fall armyworms collected in the southern United States during the summer of 1985 appeared to consist of individuals with different levels of susceptibility to insecticides (Table 1). Fall armyworm from Florida exhibited < 50% mortality compared with 85% mortality in Mississippi larvae exposed to methomyl and chlorpyrifos at 91 g/ha. Permethrin at 18.2 g/ha, methyl parathion at 91 g/ha and carbaryl at 364 g/ha resulted in < 50% mortality in Mississippi larvae. These results are similar to those of Young (1979b) who found differences in insecticide susceptibility of larvae collected in the same year from Florida, Georgia and Texas. He reported that FAW from the southeastern United States were highly resistant to carbaryl and moderately resistant to methyl parathion, but the Texas FAW was susceptible to both insecticides. Young (1979a) suggested that such susceptibility differences may assist in determining origins of FAW infestations in the United States.

Response of Jamaica and Honduras larvae to the insecticide treatments were somewhat similar to the Mississippi larvae in that only methomyl and chlorpyrifos were effective (only 50% mortality for methomyl treated Honduras larvae) against 3rd instars. Carbaryl, methyl parathion and permethrin were ineffective (0-19% mortality). The Honduras FAW population differed from both the Mississippi/Jamaica and the Florida response patterns, being more similar to Mississippi/Jamaica relative to chlorpyrifos, but closer to Florida relative to methomyl. Because of an unexplained and unexpectedly high control mortality (35%) in the Honduras FAW populations, however, these data should be considered with caution until further studies are done.

Since the FAW apparently does not overwinter in the U.S. except in the southernmost extremes, Young (1979a) suggested that differences in insecticide susceptibility between U.S. populations may reflect differences in sites from which infestations occurred. Thus, the Texas population reported as susceptible to both carbaryl and methyl parathion probably does not originate from the same source as the carbaryl-resistant, methyl parathion-tolerant population of Georgia and Florida. Similarly, in this study, the methomyl- and chlorpyrifos-susceptible Mississippi populations is probably different from the Florida FAW. Differences in response to methomyl combined with subtle differences in biological parameters (Castro & Pitre, unpublished data) further suggests
TABLE 1. Mortality of third instar S. frugiperda larvae collected in different geographical areas. 1986a.

<table>
<thead>
<tr>
<th>Formulation</th>
<th>AI/ha (g)</th>
<th>Percent mortalityb in 24h of 3rd instar larvae collected in</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mississippi</td>
</tr>
<tr>
<td>Methomyl 1.8 L</td>
<td>91</td>
<td>85 a</td>
</tr>
<tr>
<td>Chlorpyrifos 4 EC</td>
<td>91</td>
<td>85 a A</td>
</tr>
<tr>
<td>Permethrin 2 EC</td>
<td>18.2</td>
<td>35 b A</td>
</tr>
<tr>
<td>Methyl parathion 4 EC</td>
<td>91</td>
<td>34 b A</td>
</tr>
<tr>
<td>Carbaryl 80 SP</td>
<td>304</td>
<td>10 b A</td>
</tr>
</tbody>
</table>

*a Larvae collected in Mississippi and Honduras on sorghum and in Jamaica and Florida on corn.
*b Mortality adjusted using Abbott’s formula. (Average % control mortalities were: Mississippi, 10%; Florida, 5%; Jamaica, 50%; Honduras, 39%).
*c Means in columns followed by the same lower case letters and in rows followed by the same upper case letters are not significantly different at P<0.05 level by Duncan’s multiple range test.

That the Mississippi and Honduras FAWs are distinct populations. In addition, Ramaswamy & Pitre (unpublished data) have found differences in the calling rhythm of females from Mississippi and Honduras. Additional studies would be required to propose a specific relationship between the Mississippi and Jamaican FAW, though the response to insecticides reported here do not preclude such a relationship.

Differences in developmental parameters between FAW from Puerto Rico and Louisiana were sufficient for Pantoja et al. (1987) to suggest that insects from the two areas represent, to some degree, reproductively isolated populations. Pashley et al. (1985) used electrophoretic methods to genetically characterize FAW populations from Mexico, southeastern United States and the Caribbean. They reported genetic differences between populations from Puerto Rico and those from the southeastern United States and Mexico, and speculated that the source of immigrant FAW for the eastern United States may not be Puerto Rico but possibly southern Florida, Texas or Mexico. In additional studies (Pashley 1986) concluded that the FAW is composed of genetically differentiated host strains and that these strains may be reproductively isolated host races or sibling species.

The results presented in this study cannot be interpreted as conclusive evidence of the sources for migratory FAW that initiate infestations in the United States because of the small number of larvae originally obtained to start the cultures. Also the level of insecticide susceptibility of laboratory reared FAW from different geographical areas may not be a true indicator of origin. Additional studies are needed to prove this hypothesis. However, the data do indicate differences in FAW responses to insecticides. Differences in geographical isolates of NPV in FAW from areas in the United States, Central and South America and the Caribbean further suggest the existence of geographically different populations of this species (Fuxa 1987). These facts contribute to a better understanding of potential or real differences in FAW populations in different geographical areas in the Caribbean and surrounding mainlands. Additional information is gained to elucidate the influence of immigrant populations on pest establishment and development of large populations of susceptible or resistant insects in areas where insecticides are required for management of the pest. The apparent existence of migratory populations with different levels of susceptibility or tolerance (possible resistance) to insecticides in areas where the pest has the potential to overwinter (e.g., southern Florida) can have a significant impact on the development and implementation of pest management practices in areas where the immigrant populations become established.
It is important to recognize that many insecticides prove to be ineffective when applied at recommended rates to whorl stage sorghum or corn infested with mid- to late instar FAW. This is particularly evident when the insecticide is applied in low volumes of water (150-250 l/ha) (Young 1979b). In other field tests associated with the present study and conducted at the same time, FAW larvae were successfully controlled on sorghum seed heads while several of the insecticides proved to be ineffective against 3rd instar larvae in the whorl. Fall armyworm larvae feeding deep in the whorls are covered with a mixture of excrement and plant material (frass) and are not exposed to the insecticides. Larvae feeding on seed in the panicles are more exposed and thus the insecticides can be effective. These observations indicate that the FAW in Mississippi have not developed resistance to the commonly used insecticides for control of this pest and that the infestations in this area are not the result of immigrant populations from areas (e.g., Homestead, Florida) where the FAW has developed resistance to certain insecticides. The results of tests conducted in Honduras (Castro & Pitre unpublished data) indicate that 1st instar FAW are effectively controlled with methyl parathion on whorl stage corn. Like the FAW from Mississippi, which appear to be susceptible to methyl parathion and methomyl, the FAW from Honduras appear to be more like those from the mid-south in the United States than from Florida. Additional insecticide tests are planned to monitor insecticide susceptibility of FAW populations from different source areas in the southern United States and Central America to obtain information on possible relationships of the populations from the various areas. Further studies have to consider host strains (Pashley 1986) as possible explanation for variations in results of previous studies.

ENDNOTE

I thank Drs. Howard Chambers, Seth Johnson, Randy Luttrell, Dorothy Pashley, Sonny Ramaswamy, George Teetes and John Young for critically reviewing this paper, and Dr. Jorge Pena for providing me with fall armyworm eggs from southern Florida. This research was supported in part by grant AID/DSAN/XXI-G-0149 from the United States Agency for International Development to the Sorghum and Millet Collaborative Research Support Program (INTSORMIL) and was conducted as partial fulfillment of the memorandum of understanding between the Ministry of Natural Resources of the government of Honduras and INTSORMIL, Acuerdo No. 152 Tegucigalpa, D.C., February 8, 1983. The views and interpretations in this publication are those of the author and should not be attributed to USAID. Mississippi Agricultural and Forestry Experiment Station Publication Number 6743.

REFERENCES CITED


