DEVELOPMENT OF FALL ARMYWORM,
SPODOPTERA FRUGIPERDA,
FROM HONDURAS AND MISSISSIPPI ON SORGHUM
OR CORN IN THE LABORATORY

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ABSTRACT

Fall armyworm, Spodoptera frugiperda (J. E. Smith), larvae from Choluteca, Honduras and Starkville, Mississippi, U.S.A., were reared on sorghum or corn at 26 or 27°C and 14 hours of light. Head capsule widths were measured to determine instar change. Larval development time was shorter for insects from Mississippi than insects from Honduras. No difference in development time for larvae in either culture was due to the host plant. The duration of prepupal and pupal stages was not significantly different for any of the treatments. Moths from Mississippi appeared to be more fecund than moths from Honduras, and insects fed corn appeared to be more fecund than those fed sorghum.

RESUMEN

Larvas del gusano cogolito, Spodoptera frugiperda (J. E. Smith), de Choluteca, Honduras y de Starkville, Mississippi, U.S.A., se criaron en sorgo o maíz a 26 o 27°C con 14 horas de luz. Se midió el ancho de la cabeza para determinar cambios de estadio. El tiempo de desarrollo de las larvas fue más corto en los insectos de Mississippi que en los insectos de Honduras. No hubo diferencia en el tiempo de desarrollo de las larvas en ambas culturas debido a la planta hospedera. No hubo diferencia significativa en ninguno de los tratamientos en las etapas de prepupas y de pupas. Alevillas de Mississippi parecen ser más fecundas que las alevillas de Honduras, y los insectos alimentados con maíz parecieron ser más fecundos que aquellos que se les dió sorgo.
The fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith), is a polyphagous insect (Luginbill 1928,) but given a choice, it prefers to oviposit and feed on plants in the grass family (Poaceae). Within this family increased oviposition and higher larval infestations occur on corn than on sorghum when intercropped (Sifuentes 1967, Van Huis 1981, Castro et al. 1984). The number of eggs laid per FAW female varies as reported by several workers including Escañante (1974) in Peru, 400-500 eggs, Chereguino & Menendez (1975) in El Salvador, 206-1500 eggs and Randolph & Wagner (1966) in Texas, 97-2047 eggs.

Piedra (1974), working with the FAW in Cuba, found no significant differences in larval development time, adult emergence and longevity when larvae were reared on corn or sorghum. Roberts (1965) in Georgia also found no significant differences in egg to adult development time when FAW were reared on corn or grain sorghum.

FAW larvae in Brazil developed through seven instars when fed sorghum (Lordello et al. 1980), but in the United States, FAW fed corn had six instars (Pitre & Hogg 1983). FAW larvae fed wild grasses developed through seven instars (Pencee & Martin 1981). Barfield et al. (1978) constructed a temperature dependent model for development of the FAW, mortality was lower at 26.7°C than at 18° and 37°C. Pitre & Hogg (1983) observed the development of FAW larvae on three hosts including cotton, soybean and corn. Duration of the larval stage was shortest for insects fed corn. Mortality was lowest on corn and highest on soybean.

Migration of FAW adults into the continental United States from countries within and around the Caribbean has been suggested (Luginbill 1928, Mitchell 1979, Young 1979, Hogg et al. 1982). Therefore, biological comparisons of FAW cultures from these areas should be made to establish possible relationships between populations from each area. In this study the effects of host plants on several biological parameters of FAW from Honduras and the United States were observed including number of instars, duration of larval instars, prepupae and pupae, and pupal weight, as well as observations on longevity and fecundity.

**Materials and Methods**

Test 1 and Test 2. The FAW cultures were started with insects collected on sorghum in August, 1984 at La Lujosa, Choluteca, Honduras and Oktibbeha County, Mississippi, U.S.A. Insects used in this study were the F_{3} (Test 1) and F_{4} (Test 2) generations. Both cultures were maintained on a wheat germ diet (Bio-Mix 9/81, Bio-Serv, Inc.) in the laboratory in the Entomology Department at Mississippi State University.

Larvae were reared individually at 27 ± 2°C and 14:10 light-dark photoperiod in 1 oz. plastic cups with moist filter paper on the bottom to keep humidity high. The host plants growing in pots in the greenhouse included corn ('Pioneer 519') and sorghum ('Paymaster 1022') in early whorl (Test 1) and mid-whorl (Test 2). Plants were watered daily and fertilized weekly with 10-15-10 fertilizer. Food consisted of leaf tissue from the distal two thirds of leaves close to the whorl and stalk pieces. The stalk pieces were provided to larvae entering the third instar. Fresh leaf and stalk material, in excess of daily consumption, were placed in the cups daily, and old material removed.

Treatments consisted of larvae from Honduras and Mississippi (28 each = 28 replications) reared on sorghum or corn. Daily head capsule measurements of each larva were made with an ocular micrometer to determine instar change and duration. The total larval period (Tests 1 and 2) and duration of the prepupal (cessation of feeding at which time larva becomes compact with reduced length) and pupal stages (Test 2) were determined for each treatment. Additionally, pupa were weighed (day 2) and some preliminary observations were made on adult longevity and fecundity in test 2. Newly emerged
adults (1♀ + 2♂) were confined in 1 pint cartons with a nylon mesh cover. A 5% honey water solution was added for food and wax paper was used as an oviposition surface. Egg masses were recorded and the number of eggs per mass was determined by weight measurements using the equation by Lynch et al. (1988).

Test 3. A separate test was conducted to specifically obtain additional information on longevity and fecundity of FAW moths. Methods used to rear larvae and test adults were the same as in test 2 except that the temperature was 26 ± 3°C.

Data were analyzed as a completely random design and means were separated by Duncan's multiple range test (Duncan 1955).

RESULTS AND DISCUSSION

Test 1. When FAW larvae from Honduras and Mississippi were reared on corn or sorghum, no differences were observed among the four treatment combinations in the width of the head capsule for any given larval instar. Head width measurements were similar to those reported by Ashley (1983). Larvae from each culture developed through six instars when fed either host. Morphological similarities between the larval growth stages within the two cultures will be particularly useful in comparative biological studies (e.g., in analyzing parasitization of FAW larvae when head capsule measurements are used to identify the age structure of individual larvae collected in the field).

Pitre & Hogg (1983) observed that corn-fed FAW larvae had six instars. This is similar to our observations, but Lordello et al. (1980) found that FAW larvae fed sorghum had seven instars. This might reflect a difference between FAW from Brazil and FAW from Honduras and Mississippi. The existence of a geographical isolate of FAW in Brazil different from FAW in the Caribbean area has been proposed by Fuxa (1987) based on susceptibility of the insects to geographical isolates of nuclear polyhedrosis virus.

The time in development of 1st, 2nd and 6th larval instars was not significantly different within instars; some differences, although not consistent, were observed among the 3rd, 4th and 5th larval instars (Table 1). The total time of development for larvae from Mississippi (corn = 12.5 d, sorghum = 12.6 d) was shorter than that for larvae from Honduras (corn 13.1 d, sorghum 13.3 d). Development times on diets of sorghum were similar to those of corn for larvae from both areas; similar observations were made by Roberts (1965) and Piedra (1974).

Test 2. In a second series of observations, insects from Mississippi (corn 11.4 d, sorghum 11.4 d) also developed faster than those from Honduras (corn 12.5 d, sorghum 12.2 d);

<table>
<thead>
<tr>
<th>Source</th>
<th>Host</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>C</td>
<td>2.0a</td>
<td>2.0a</td>
<td>1.7a</td>
<td>2.0ab</td>
<td>2.5ab</td>
<td>3.0a</td>
<td>13.1a</td>
</tr>
<tr>
<td>H</td>
<td>S</td>
<td>2.0a</td>
<td>2.0a</td>
<td>1.6a</td>
<td>2.2a</td>
<td>2.5a</td>
<td>3.1a</td>
<td>13.3a</td>
</tr>
<tr>
<td>M</td>
<td>C</td>
<td>9.3a</td>
<td>2.0a</td>
<td>1.2b</td>
<td>2.0ab</td>
<td>2.1b</td>
<td>3.0a</td>
<td>12.5b</td>
</tr>
<tr>
<td>M</td>
<td>S</td>
<td>2.0a</td>
<td>1.9a</td>
<td>1.5a</td>
<td>1.7b</td>
<td>2.4ab</td>
<td>3.1a</td>
<td>12.6b</td>
</tr>
</tbody>
</table>

1 H = Honduras; M = Mississippi.
2 C = corn; S = sorghum.
3 Means in a column followed by the same letter are not significantly different at the P = 0.05 level by Duncan's multiple range test.
TABLE 2. DURATION OF IMMATURE STAGES, PUPAL WEIGHT AND ADULT LONGEVITY OF FALL ARMYWORM FROM HONDURAS AND MISSISSIPPI REARED ON CORN OR SORGHUM. (TEST 2, 27 ± 2°C, 14:10 L/D).

<table>
<thead>
<tr>
<th>Source</th>
<th>Host</th>
<th>Duration of stage (x d)</th>
<th>Pupal weight (x g)</th>
<th>Longevity (x d)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Larvae</td>
<td>Prepupa</td>
<td>Pupa</td>
</tr>
<tr>
<td>H</td>
<td>C</td>
<td>12.5 a</td>
<td>1.4 a</td>
<td>9.7 a</td>
</tr>
<tr>
<td>H</td>
<td>S</td>
<td>12.2 a</td>
<td>1.4 a</td>
<td>9.8 a</td>
</tr>
<tr>
<td>M</td>
<td>C</td>
<td>11.4 b</td>
<td>1.3 a</td>
<td>10.3 a</td>
</tr>
<tr>
<td>M</td>
<td>S</td>
<td>11.4 b</td>
<td>1.6 a</td>
<td>9.8 a</td>
</tr>
</tbody>
</table>

1H = Honduras; M = Mississippi.
2C = corn; S = Sorghum.
3Means in a column followed by the same letter are not significantly different at the P = 0.05 level by Duncan's multiple range test.

no differences were observed within cultures when fed sorghum or corn (Table 2). Pre-pupal and pupal periods for the different treatments were also similar.

Pupae from the Honduras larvae fed sorghum weighed less than those from Mississippi fed the same diet (Table 2). Pupal weights for the two cultures fed corn did not differ. Pupal weight for insects fed corn was only somewhat higher (3-13 mg) than that reported by Pitre and Hogg (1983). Piedra (1974) found lower pupal weights for insects fed sorghum than those fed corn. In the present study, pupal weights for insects fed sorghum or corn were similar.

Although only a small number of adults (5♀ + 10♂ Honduras; 7♀ + 14♂ Mississippi) were included in longevity observations, FAW from Honduras appeared to survive somewhat longer (♀ = 13.0 d; ♂ = 11.8 d) than those from Mississippi (♀ = 9.3 d; ♂ = 8.4 d); adults from Honduras generally lived longer when larvae were fed sorghum (13.6 d) than corn (11.2 d), while the reverse was true for adults from Mississippi (11.3 d corn vs. 6.3 d sorghum) (Table 2). The sex ratio of FAW from Honduras was almost 2 females:1 male (n = 36♀:20♂) but the reverse was true for insects (20♀:36♂) from Mississippi (Table 3). The proportion of males to females in one culture was substantially different from the other culture. Observations on fecundity were made, but the number of moths used was small due to the small number of insects surviving to adults. Although not significant, insects fed corn laid more egg clusters and total number of eggs than those fed sorghum in both colonies. Moths from Mississippi laid more egg clusters and total number of eggs than moths from Honduras.

TABLE 3. REPRODUCTIVE TRAITS OF FALL ARMYWORM FROM HONDURAS AND MISSISSIPPI REARED ON CORN OR SORGHUM. (TEST 2, 27 ± 2°C, 14:10 L/D).

<table>
<thead>
<tr>
<th>Source</th>
<th>Host</th>
<th>Sex ratio ♀ : ♂</th>
<th>x no. egg clusters/♀</th>
<th>x no. eggs/♀</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>C</td>
<td>1:0.56</td>
<td>2.0 (3) a</td>
<td>321.2 a</td>
</tr>
<tr>
<td>H</td>
<td>S</td>
<td>1:0.56</td>
<td>1.5 (2) a</td>
<td>87.7 a</td>
</tr>
<tr>
<td>M</td>
<td>C</td>
<td>1:2.11</td>
<td>9.3 (4) a</td>
<td>1076.6 a</td>
</tr>
<tr>
<td>M</td>
<td>S</td>
<td>1:1.55</td>
<td>3.0 (3) a</td>
<td>237.9 a</td>
</tr>
</tbody>
</table>

1H = Honduras; M = Mississippi.
2C = Corn; S = Sorghum.
3Means in a column followed by same letter are not significantly different at the P = 0.05 level by Duncan’s multiple range test.
TABLE 4. SEX RATIO, FECUNDITY AND LONGEVITY OF FALL ARMYWORM FROM HONDURAS AND MISSISSIPPI REARED ON CORN OR SORGHUM (TEST 3, 26 ± 3°C, 14:10 L/D).

<table>
<thead>
<tr>
<th>Source</th>
<th>Host</th>
<th>Sex ratio</th>
<th>≤ no. eggs clusters/♀ (n)</th>
<th>≥ no. eggs/♀</th>
<th>Longevity</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>C</td>
<td>1:0.91</td>
<td>3.1 (12) a²</td>
<td>219.5 ab</td>
<td>10.27 a</td>
</tr>
<tr>
<td>H</td>
<td>S</td>
<td>1:0.55</td>
<td>3.4 (12) a</td>
<td>160.7 b</td>
<td>8.85 a</td>
</tr>
<tr>
<td>M</td>
<td>C</td>
<td>1:1.08</td>
<td>4.3 (24) a</td>
<td>306.1 a</td>
<td>9.95 a</td>
</tr>
<tr>
<td>M</td>
<td>S</td>
<td>1:1.17</td>
<td>4.2 (24) a</td>
<td>221.7 ab</td>
<td>10.3 a</td>
</tr>
</tbody>
</table>

¹H = Honduras; M = Mississippi.
²C = Corn; S = Sorghum.
*Means in a column followed by same letter are not significantly different at the P = 0.05 level by Duncan's multiple range test.

Test 3. In the third test, initiated with 24 and 48 from Honduras and 40 and 80 from Mississippi, there were no significant differences in longevity and number of egg masses or number of eggs laid per female for insects from Honduras or Mississippi (Table 4). However, the same trend for higher oviposition for moths from Mississippi than for moths from Honduras was observed, as well as a trend for higher oviposition for insects fed corn compared with those fed sorghum. A sex ratio of more females than males for FAW from Honduras was observed compared with more males than females for FAW from Mississippi. These same results were observed in test 2.

CONCLUSIONS

Fall armyworm larval development time was shorter for insects from Mississippi than insects from Honduras. Female FAW from Mississippi seem to be more fecund than those from Honduras. Longevity of adults from the Mississippi culture was reduced when larvae were fed sorghum compared to corn (one of two tests); adults from Honduras appeared to survive equally well when larvae were fed sorghum or corn. Differences indicate that the FAW from Honduras and Mississippi exhibit slightly different biological characteristics. This information might suggest that FAW populations from southern Honduras and Mississippi are different. Results of insecticide and virus susceptibility studies and observations on developmental periods of FAW from different areas in the Caribbean and in Central and South America suggest that differences in FAW populations may result from geographical isolation. Insecticide susceptibility of FAW larvae from Florida differed from insects collected in Honduras, Jamaica and Mississippi (Pitre 1986). In comparing susceptibility of FAW to geographical isolates of nuclear polyhedrosis virus, (Fuxa 1987) observed that populations from Texas and Louisiana, and areas around the Gulf of Mexico and Puerto Rico showed similar responses compared with FAW from Brazil. Sources near each other appeared to be more closely related than the geographically isolated source from Brazil. Differences in development parameters between FAW from Puerto Rico and Louisiana were sufficient for Pantoja et al. (1987) to suggest that insects from the two areas represent reproductively isolated populations. Pasley et al. (1986) 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, Pasley (1986) concluded that
the FAW is composed of genetically differentiated host strains and that thec strains may be reproducively isolated host races or sibling species.

These observed similarities or differences in populations of this important pest contribute to our understanding of the relationships of geographical sources and the initiation of infestations by immigration into areas where the insect is not indigenous. Additionally, information on relationships of FAW populations, particularly migratory habits and susceptibility to insecticides, can be useful in planning defense strategies including survey and prediction of pest problems and development of control programs.

As 93% of the sorghum in Honduras is grown in association with corn (Donaire 1982), the effect of the host plant on development of the FAW is of particular importance in understanding the population dynamics of this pest in intercropping systems. Trends (although not significant in 2 tests) for higher pupal weights were observed for insects in both cultures when fed corn compared with sorghum, as well as higher numbers of egg clusters and eggs per female. In nature, this difference could have an effect on the population dynamics of FAW in intercropping systems in Honduras. The intercropping of sorghum with corn would have an overall impact of reduced infestation of FAW in the field as opposed to that in a corn monoculture. No difference in larval development time occurred when larvae fed on corn or sorghum. This would result in similar times for development of this pest on sorghum or corn in a sorghum-corn intercropping system. However, the lower pest populations developing throughout the growing season in the sorghum-corn intercropping systems, the cropping practice used by subsistence farmers, would result in less plant damage and possibly higher crop yields.

More extensive observations are needed on adult longevity and fecundity in relation to diet and temperature. This information will be useful in understanding the development of FAW populations on sorghum and corn, and also in determining the seasonal synchrony of pest infestation and crop phenology for application of insect pest management procedures. Such an investigation was reported by Barfield & Ashley (1987) in which corn phenology and temperature affected FAW larval development, food consumption, and adult female longevity and fecundity. They also reported that developmental times were temperature-dependent and were modified by the stage of corn consumed. Additionally, biological comparisons between FAW cultures from the different geographical areas will provide useful information on movement (immigration) of FAW.

Endnote

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References Cited


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 prueban en el laboratorio para determinar su susceptibilidad al carbaryl, permethrin, methomyl, chlorpyrifos, y metilo de paración, usando hojas de plantas de sorgo rociadas 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 larvailes 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