SURVIVAL OF FALL ARMYWORM,
SPODOPTERA FRUGIPERDA, (LEPIDOPTERA: NOCTUIDAE)
EXPOSED TO COLD TEMPERATURES

R. F. FOSTER AND R. H. CHERRY
University of Florida
Institute of Food and Agricultural Sciences
Everglades Research and Education Center
P. O. Drawer A
Belle Glade, FL 33430

ABSTRACT

All life stages of seasonally aclimatized fall armyworms, Spodoptera frugiperda (J. E. Smith), were subjected to temperatures of 0, –2.5, –5, –7.5, and –10°C for 3 h in a temperature cabinet. The adult stage was most susceptible to cold temperatures, with only 26% of the moths surviving at –5°C and no survival at the colder temperatures. The egg was the most tolerant stage, with 30% survival at –10°C. Fall armyworm pheromone traps located near Belle Glade, Fla. were checked weekly during the winters of 1985-86 and 1986-87. Seven nights of subfreezing temperatures during those two winters resulted in little or no adult mortality. Our study, which included lethal temperature data, microclimate data, and field population data, shows that extreme low temperatures are not important mortality factors on fall armyworm populations in southern Florida.

RESUMEN

Todas las etapas de vida del aclimatizado a la estación del gusano cogollero, Spodoptera frugiperda (J. E. Smith), fueron expuestas a temperaturas de 0, –2.5, –5, –7.5, y –10°C por 3 h en un gabinete refrigerado. La etapa adulta fue la más susceptible a temperaturas frías, con solamente 26% de polillas supervivientes a –5 °C y ninguna supervivencia en las temperaturas más frías. El huevo fue la etapa más tolerante con 30% de supervivencia a –10°C. Las trampas de feromonas del gusano cogollero localizadas cerca de Belle Glade, Fla. fueron verificadas semanalmente durante el invierno de 1985-86 y 1986-87. Siete noches de heladas temperaturas durante esos inviernos dieron por resultado pocas o ninguna mortalidad en los adultos. En un estudio el cual incluye datos de temperaturas letales, datos de microclima, y datos de población en los campos, muestran que temperaturas extremadamente bajas no afectaron lo suficiente como para causar una gran mortalidad en la población de gusano cogollero, en el sur de la Florida.

The fall armyworm (FAW), Spodoptera frugiperda (J. E. Smith), is a polyphagous pest whose annual damage and cost of control in the U.S. has been reported to be as high as $300 million (Entomol. Soc. Amer. 1979). FAW adults will typically emigrate from their overwintering range during early spring to infest more northern states (Luginbill 1928). In mild winters FAW can survive in parts of Florida, Louisiana, and Texas but during normal or severe winters the overwintering range is limited to southern Florida and southern Texas, as well as more tropical locations (Chittenden 1900, Hinds & Dew 1915, Luginbill 1928, Vickery 1929, Snow & Copeland 1969, Tingle & Mitchell 1977). Several researchers have noted FAW overwintering survival in Florida.
Tingle & Mitchell (1977) reported that FAW normally overwinter in a salubrious area around Hastings, Fla. (29° 43'N). Wood et al. (1979) investigated direct effects of extended periods of cold temperature on survival of pupae in Florida. Waddill et al. (1982) found that FAW could overwinter in south Florida (25° 30'N) even in severe winters and could sometimes overwinter as far north as Gainesville, Fla. (29°38'N). Pair & Sparks (1986) estimated the overwintering range of FAW to be south of ca. 28° N latitude in south Florida. Since southern Florida is an important overwintering site for FAW, our objective was to more fully determine the effect of extreme cold temperatures on survival of all FAW life stages under southern Florida field conditions.

**Materials and Methods**

During fall 1986, a FAW colony was established in an outdoor screen house using field-collected insects. Most FAW were free to move about within the screen house and fed on hybrid sweet corn growing in pots, while other FAW in the screen house were maintained in 1 oz plastic cups and fed artificial diet (Shorey & Hale 1965). FAW were chosen from both sources for all tests. All FAW used in our temperature tests were maintained outdoors in this screenhouse so that the insects would be seasonally acclimatized. Seasonal acclimatization can be an important factor in the survival of insects subjected to extreme temperatures (Salt 1961, Bursell 1974). The test insects were collected from the colony and exposed to experimental temperatures within 1 h after collection in a glass jar (0.95 liter) with a thermometer through the lid to monitor the temperature within the jar. Approximately 10 individuals of each developmental stage were put into the jar for each test. Several corn leaves were placed in the jar to provide a resting site for adults and large larvae (4th-6th instar). Eggs, small larvae (1st-3rd instar), and corn leaves were placed in two screen-topped 37 mm diameter metal cans so that the eggs and small larvae would not get lost or crushed in the jar. The tests were conducted in an environmental chamber and the temperature was checked every 30 min to ensure maintenance of a constant temperature (± 0.5°C) within the jar. After reaching the test temperature, the duration of exposure to each temperature was 3 h because thermograph records collected over several years from a weather station at the Everglades Research and Education Center at Belle Glade, Fla. (26° 40'N) showed that extreme low temperatures on winter mornings were almost always of short duration, usually ca. 3 h. Live insects were counted during a 2 h observation period after the temperature exposure because insects recorded as live during that period remained alive and insects that appeared dead still appeared dead the following day. The FAW eggs were stored on moist filter paper in petri dishes at room temperature (ca. 25°C) either until hatch or until it was obvious that hatching would not occur (ca. 10 days). Each jar containing all FAW stages exposed to a specific temperature was considered a replicate and only one replicate was tested on any one day. Four replicates were made at each of the 5 test temperatures (0, −2.5, −5, −7.5, and −10°C); all tests were conducted between 3 Dec. 1986 and 20 Mar. 1987.

Bursell (1974) stated that when studying the effects of temperature on insect survival, it is important to measure the temperature of the microenvironment, rather than just the general environment. Microclimate temperatures experienced by FAW in southern Florida cornfields were measured with a portable thermometer with a surface temperature probe (4.5 mm diameter). Air temperatures were measured 0.5 m above ground. Leaf temperatures were taken from corn leaves 0.3 m aboveground by taping the probe to the undersurface of the leaf, where an egg mass would usually be oviposited. Whorl temperatures were measured by gently sliding the probe down into the whorl of a corn plant, where larvae would typically be found. Soil temperatures were
determined by placing the probe 2 cm below the soil surface and gently packing soil around it. FAW larvae drop to the ground and pupate 2-7 cm below the soil surface (Luginbill 1928). Each of these temperatures was measured every 10 min at different sites in a cornfield between 0500 and 0600 hours (EST) on 19 Mar. 1987. This hour was chosen because extreme cold normally occurs during this hour in southern Florida.

Four cone traps (Hartstack et al. 1979) baited with a 4-component FAW pheromone supplied by Terenech Laboratories Ltd. were checked weekly during December-March of 1985-86 and 1986-87. Three of the traps were located on the 325 ha Everglades Research and Education Center farm and the fourth trap was located on a local farm approximately 16 km away. Temperature data collected at the weather station at our research center at Belle Glade were compared with the moth catches in the pheromone traps to determine how the 7 nights of sub-freezing weather experienced during those two winters affected FAW moth catches.

Mean survival of various stages were compared at each test temperature using Duncan's (1955) multiple range test.

RESULTS

Table 1 summarizes the results of the exposure of the FAW life stages to various cold temperatures for 3 h. The egg stage was the most tolerant and the adult stage was the least tolerant to cold temperatures. There was no significant reduction in egg survival until −10.0°C and even at this coldest test temperature, 30.3% of the eggs survived. Small larvae also did not experience a significant loss in survivability until exposed to −10°C, but no survival was observed at this temperature. Large larvae, pupae, and male and female adults had significant reductions in survival at −5.0°C. No adults survived at −7.5 or −10.0°C. At −10.0°C, 5% of the pupae survived.

The temperatures measured on the undersurface of a corn leaf, in the whorl of a corn plant, and 2 cm below the soil surface were virtually the same as the ambient air temperatures. Therefore, it can be assumed that air temperature measured 0.5 m aboveground is a good estimator of the temperatures experienced by FAW. On 26 Dec. 1985, the air temperature at the research center dropped to −1.1°C. The mean FAW moth catch in the four pheromone traps during the week prior to the freeze was 49 moths per trap. The mean catch during the week of the freeze was 29 and the mean catch the following week was 56 moths per trap. A more severe freeze was experienced on 28 and 29 Jan. 1986, when the low temperatures were −3.3 and −2.8°C, respectively. The mean moth catches in this instance increased from 45 to 46 during the week of the

TABLE 1. MEAN PERCENTAGE1 SURVIVAL OF WINTER ACCLIMATIZED FALL ARMYWORM LIFE STAGES EXPOSED TO COLD TEMPERATURES FOR 3 H.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Eggs</td>
<td>91.0 a</td>
</tr>
<tr>
<td>Small larvae</td>
<td>95.0 a</td>
</tr>
<tr>
<td>Large larvae</td>
<td>100.0 a</td>
</tr>
<tr>
<td>Pupae</td>
<td>100.0 a</td>
</tr>
<tr>
<td>Adult males</td>
<td>88.3 a</td>
</tr>
<tr>
<td>Adult females</td>
<td>88.3 a</td>
</tr>
</tbody>
</table>

1 Means within a row followed by the same letter are not significantly different (P ≤ 0.05), Duncan’s (1955) multiple range test.

2 Small larvae = instars 1-3; large larvae = instars 4-6.
freeze and dropped to 35 the following week. Low temperatures of -1.7 and 0°C were measured on 2 and 3 Mar. 1986. The mean moth catches were 47, 28, and 19 moths per trap for the weeks before, during, and after the freezes, respectively. Finally, during two consecutive trapping periods in Jan. 1987, the low temperature reached -0.6°C on 24 and 28 Jan. This time the mean trap catches increased from 24 moths per trap during the week prior to the first freeze to 184 and 158 moths per trap during the next two weeks. Many factors may affect pheromone trap catch such as population size, wind, and temperature. However, overall our trap catch data show that subfreezing temperatures of short duration during the winters of 1985-86 and 1986-87 had little effect in reducing FAW field populations, which is consistent with our laboratory data.

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REFERENCES CITED


