LARVAL DEVELOPMENT AND SURVIVAL OF THE BOLLWORM ON COTTON[1]

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ABSTRACT - Five larval instars of the bollworm, *Heliothis zea* Boddie were fed on five cotton plant parts and an artificial diet. Their effects on larval development and survival were analysed. The results showed that the highest mortality in first instar was for those placed on bolls. For the second and third instars, flowers, bolls, squares and leaves proportionated the highest percentages of survival. The lowest survival rate for the fourth instars was found on squares. The fifth instars showed high rates of survival on bolls, leaves and the artificial diet. Larval establishment was highly significant for larvae fed on flowers when compared with those fed on bolls. Larvae fed on terminal, leaves and squares took the longest time to reach the sixth instars. Pupae from artificial diet, bolls, and leaves were the heaviest.

Index terms: *Heliothis zea,* larval weight, feeding preference, larval instar.

SOBREVIVÊNCIA E DESENVOLVIMENTO DA LAGARTA-DA-MAÇÃ NO ALGODOEIRO

RESUMO - Cinco estruturas da planta do algodoeiro, e como padrão, uma dieta artificial, foram usadas na alimentação de cinco estádios da lagarta-da-maçã *Heliothis zea* Boddie. Os resultados mostraram que a maior mortalidade ocorreu em larvas do primeiro estádio alimentadas em maçãs. Larvas do segundo e terceiro estádios alimentadas em flores, maçãs, botões florais, folhas, obtiveram as maiores percentagens de sobrevivência. As mais baixas taxas de sobrevivência foram observadas em larvas do quarto estádio alimentadas em botões florais. Larvas alimentadas em flores, botões florais e folhas tiveram altas percentagens de estabelecimento e foram significativamente diferentes das alimentadas em maçãs. Larvas alimentadas em folhas, terminais e botões florais demoraram mais tempo para atingir o sexto estádio. As pupas mais pesadas foram oriundas de larvas alimentadas em dieta artificial, maçãs e folhas.

Termos para indexação: *Heliothis zea,* preferência para alimentação, estádio de larva.

INTRODUCTION

Study of development and survival of the immature stages of the bollworm, *Heliothis zea* (Boddie), are important for an understanding of the biology and behavior of this pest. It is known that *Heliothis* spp. larvae have distinct feeding preferences, especially for cotton flowers and small bolls with dried flower corollas adhering to them (Farrar Junior & Bradley Junior 1985). Thus, it is essential that the effects of different parts of the plant on the development and survival of immature stages of the bollworm can be measured with information about developmental times, weight, and rate of survival.

In general, newly hatched larvae do not immediately search for food, but consume the chorion of the egg. They then begin searching for other food, particularly tender tissues of the cotton plant. Small larvae are quite mobile on the cotton plant, but when a square is located, feeding begins (Quaintance & Brues

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1905, Bishopp 1929). Studies conducted by Reese et al. (1981) showed that more than 50% of damage occurs on squares less than 6 mm in diameter. In addition, they found that larvae feed most heavily on the anthers.

Burkett et al. (1983), studying the behavior of *H. Zea* on tomatoes (*Lycopersicum esculentum* L.), found that first instar larvae, when placed on flowers, fed there for at least four days. As the feeding declined on flowers, they started feeding on leaves and on fruits. Terry et al. (1987) found that *H. zea* larvae, fed on prebloom stages of soybean, weighed more than those fed on bloom or podfill stage plants. Quaintance & Brues (1905) reported that a bollworm larva may consume parts of 19 cotton squares during its larval life. They determined that the average consumption per larva is eight squares, one flower, and two bolls. However, Lincoln et al. (1967) showed that each bollworm larva can damage an average of 3.8 squares and 2.2 bolls. Isely (1935) stated that *H. zea* is essentially a borer and by preference feeds within the fruiting structures of plants or plant stems rather than externally upon them.

Farrar Junior & Bradley Junior (1985) found that cotton flowers and artificial diet produce the highest percentages of larval establishment and shortest developmental times of bollworm. In addition, they found that the heaviest pupae were produced from treatment which included bolls. It is hypothesized that the survival and behavior of the bollworm might be strongly influenced by the site of initial contact of the larvae with the plant.

These studies are an attempt to determine the effect of cotton plant squares, flowers, bolls, and main stem terminals on larval development and survival.

MATERIALS AND METHODS

These studies were conducted in constant temperature chambers set at 26 ± 1°C (day) and 24 ± 1°C (night), 14:10 (L-D) photoperiod, and 65% R.H. Five plant parts, including leaves, squares, flowers, bolls, and main stem terminals were used. In addition, an artificial diet (Burton 1970) was included to compare with plant parts. Plant parts were collected from the field and each prepared with a 12 cm stem section. They were individually examined for eggs, larvae, and predators before being placed into the cups. Rearing containers consisted of plastic cups (350 ml) each, with a 1 cm hole in the button. Two like plant parts were placed in the cup with stems inserted into another cup containing water.

This experiment consisted of six treatments (rows of cups in the chamber), and eight replicates (racks of cups in the chamber) in a randomized complete block design. Treatments consisted of the different plant parts and the artificial diet.

Initially, each cup with two plant parts was infested with three neonate larvae. The cups were covered with clear plastic lids through which pin-holes were made to allow air movement. Plant parts were replaced every three days, except flowers, which were replaced every day. Before the replacement of plant parts, the number of surviving larvae and their instars were recorded, based on head capsule measurements, according to Dyar (1980). From third of fifth instars, only one larva was put in each cup due to occurrence of cannibalism. If, in a cup no living larva was found, a replacement was made by using a larva of the same instar, taken from a colony fed on the same type of plant part.

When at least two larvae in a given cup reached the third instars, they were considered established; the date of establishment and number of survival larvae were then recorded. When larvae reached the fifth instars, they were transferred to a small cup (30 ml) with wheat germ to facilitate pupation, and 5 g of artificial diet in order to supply the final feeding requirements before pupation. The numbers of days required to reach the sixth instars were recorded, as well as pupal weights and time until adult emergence.

The experiments were analyzed by analyses of variance procedures (SAS Institute, 1985). Mean separations were determined by Waller-Duncan tests (P = 0.5) in a randomized complete block design.

RESULTS AND DISCUSSION

The highest mortality (93.8%) observed in first instars was for those placed on bolls. The

highest percentage of survival (54.7%) of first instars were on artificial diet. Survival larvae on leaves, squares, and flowers were not significantly different, but they were different than those on bolls (Table 1). The damage caused by first instars on any plant part was not easily seen without using a binocular microscope. The lowest rate of survival on bolls is probably due to toughness surface of bolls. The highest percentage of survival on terminals and leaves indicate that these plant parts offer a suitable feeding site for neonate larvae. These results agree with the findings of Braga Sobrinho et al. (1988), except for flowers, which were the highly preferred feeding site for first instar larvae, whereas in the survival test flowers were inferior to terminals.

For the second instar, flowers, bolls, squares, and leaves proportionated the highest percentages of survival, comparable to artificial diet. The lowest percentages of survival were recorded for larvae fed on terminals and leaves, which were not significantly different. In the third instars, bolls, flowers, squares, and leaves had the highest rate of survival. The lowest rate of survival was observed on terminals. Survival on terminals was not significantly different from survival on leaves, squares, and flowers. The third instars showed high preference for feeding on the stems of plant parts. Stems of leaves and terminals were usually bored into by these larval instars. Consequently, stem dissections were usually required in order to find a hidden larva.

Survival of fourth instars was high on bolls, flowers, leaves, and terminals. There were no differences among bolls, flowers, leaves, terminal, and artificial diet. The lowest survival rate was found on larvae fed on squares, which was significantly different from that on bolls, artificial diet, and flowers. The reason why survival rates of larvae fed on terminals and leaves was high is probably due to the use of the stems of these plant parts as a food source. This may indicate that the stems of these plant parts supply these larvae with essential food sources of their survival. The fifth instars showed high rates of survival on bolls and leaves. The lowest percentages of survival were found on terminals and squares. Survival on bolls, flowers, leaves, and artificial diet were not significantly different.

Larval establishment was highly significant for larvae fed on flowers, squares, and leaves when compared with those fed on bolls. The lowest percentages of establishment were obtained in larvae fed on bolls (Table 2). This may indicate that larvae fed on bolls did not reach the third instars as fast as when fed on their plant parts.

Larvae fed on terminals, leaves, and squares took the longest time to reach the

TABLE 1. Percentages of survival of bollworm larvae fed on different cotton plant parts and artificial diet.

Plant parts	Instar				
	First	Second	Third	Fourth	Fifth
Artif. diet	54.7 A	66.1 A	96.9 A	100.0 A	100.0 A
Terminal	44.5 B	44.5 B	75.0 B	87.5 AB	78.1 C
Leaf	40.6 BC	63.4 AB	81.2 AB	90.6 AB	96.8 AB
Squares	35.2 C	68.7 A	84.4 AB	78.1 B	84.3 C
Flower	35.2 C	78.6 A	90.6 AB	93.7 A	87.5 BC
Boll	6.2 D	78.1 A	93.7 A	100.0 A	96.8 AB

Within each column, means followed by the same letter are not significantly different ($P<0.05$; Duncan's (1955) new multiple range test).

TABLE 2. Trends of bollworm development from larva to adult fed on cotton plant parts and artificial diet.

Plant part	% Larvae establish.	No. days 6th instar	Pupa weight (mg)	No. days adult emerg.
Artif. diet	47.9 A	11.1 D	482.1 A	30.6 D
Terminal	26.0 C	17.9 A	426.9 B	38.4 A
Leaf	33.3 BC	17.8 A	470.5 A	36.5 B
Squares	30.2 BC	18.1 A	432.0 B	36.5 B
Flower	32.0 B	12.8 C	435.7 B	32.0 C
Bolls	12.0 D	13.0 C	478.0 A	35.0 B

Within each column, means followed by the same letter are not significantly different ($P<0.05$; Duncan's (1955). Multiple range test).

sixth instars. They were not significantly different from each other. The shortest time was obtained from larvae fed on diet. Pupae from artificial diet, bolls, and leaves were the heaviest. They were significantly different when compared to pupae from terminals, squares, and flowers.

CONCLUSIONS

1. The feeding sequence of neonate and more mature larval instars begins with the response to certain tactile, chemical, olfactory, and gustatory stimuli that maintain the larvae on the host and stimulate them to feed. These studies present evidence that bollworm larvae can accept, establish, and develop on various cotton plant parts such as main stem terminals, leaves, squares, flowers, and bolls. The highest percentages of mortality occurred during the establishment period. The highest percentages of mortality, over 90%, occurred during the first instars on larvae fed on bolls. For the fifth and sixth instars, the highest mortality occurred on squares and terminals, respectively.

2. Larval establishment was high on artificial diet and flowers. Days to reach the sixth instars were shorter on flowers. Pupal weights were higher on diet, bolls, and leaves. Numbers of day for adult emergence were lower on artificial diet and on flowers.

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