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The feeding preferences of *Spodoptera frugiperda* (J. E. SMITH) (Lepidoptera: Noctuidae) on cotton plant varieties

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ABSTRACT. This work evaluated the attractiveness and the non-preference for feeding of newly hatched fall armyworm larvae on the cotton plant parts and different varieties used in the study. The trials were performed at 27 ± 1ºC, a 70% ± 10% relative humidity and a 14h photoperiod. Leaves, bracts, squares and carpel walls of the BRS Itamarati-90 variety and leaves of Fibermax-966, Fibermax-977, DeltaOpal, DeltaPenta, BRS Acala-90, Coodetec-408, Coodetec-409, Coodetec-410, BRS-Cedro, BRS-Ipê, BRS-Aroeira, IPR-96, IPR-120, BRS-Araçá, IAC-24 and BRS Itamarati-90 varieties were used in attractiveness, multiple-choice and confinement (no-choice) non-preference feeding trials. Twenty larvae were released per petri dish test (arena system) with 10 repetitions. Attractiveness trials were evaluated by counting feeding caterpillars over 60 min. and by measuring non-preference at 24h. Leaves were the most attractive item and were preferred for feeding. In the multiple-choice arena trials, Coodetec-410 was the most attractive variety, and BRS Acala-90, Fibermax-966 and DeltaPenta were the least attractive to fall armyworm larvae. In the non-preference trial, BRS-Araça was the variety favored for feeding. BRS-Cedro, BRS Itamarati-90, DeltaPenta, Coodetec-408 and BRS-Aroeira were the least-favored varieties. In the 60 min. attractiveness trials, 46 min. proved to be the most suitable time for evaluating the attractiveness of cotton plants to newly hatched fall armyworm larvae.

Keywords: plant resistance, *Gossypium hirsutum*, fall armyworm.

Preferência alimentar de *Spodoptera frugiperda* (J. E. SMITH) (Lepidoptera: Noctuidae) em variedades de plantas algodoeiras

RESUMO. Avaliou-se atratividade e não-preferência alimentar de lagartas recém-eclodidas de *Spodoptera frugiperda* por partes de plantas e plantas de variedades de algodoeiro. Testes foram realizados a 27 ± 1ºC, UR de 70% ± 10% e fotofase de 14h. Folhas, brácteas, botões florais e cascas de maçãs da variedade BRS Itamarati-90 e folhas de Fibermax-966, Fibermax-977, DeltaOpal, DeltaPenta, BRS Acala-90, Coodetec-408, Coodetec-409, Coodetec-410, BRS-Cedro, BRS-Ipê, BRS-Aroeira, IPR-96, IPR-120, BRS-Araçá, IAC-24 e BRS Itamarati-90 foram utilizadas nos testes de atratividade e não-preferência para alimentação, com e sem chance de escolha. Utilizaram-se 20 lagartas de *S. frugiperda* por placa de Petri (sistema de arena) por teste, com 10 repetições. Contaram-se lagartas para avaliar atratividade por 60 min e não-preferência para alimentação por 24 h. Folha foi mais atrativa e preferida para alimentação por lagartas de *S. frugiperda*. Em livre escolha, Coodetec-410 foi mais atrativa e BRS Acala-90, Fibermax-966 e DeltaPenta, as de menor atratividade à *S. frugiperda*; BRS-Araçá, mais preferida para alimentação e BRS-Cedro, BRS Itamarati 90, DeltaPenta, Coodetec-408 e BRS-Aroeira, menos preferidas. Considera-se 46 min., tempo mais adequado para avaliar atratividade de algodoeiro a lagartas de *S. frugiperda*.

Palavras-chave: resistência de plantas, *Gossypium hirsutum*, lagarta-do-cartucho.

Introduction

The fall armyworm, *Spodoptera frugiperda* (J. E. Smith), a native species of tropical and subtropical regions of the Americas, is geographically widespread (LUGINBILL, 1928) and feeds on a wide range of cultivated plants (LUGINBILL, 1928). Although the fall armyworm prefers to feed on plants of the grass family (maize, millet, wheat, sorghum, rice and sugar cane), it will attack other such economically important crops as peanuts, potato, soybean and cotton (ALI et al., 1989).

The fall armyworm, considered one of the chief pests of maize in North America (WISEMAN et al., 1966), finds the climate of Brazil favorable and

encounters diverse food items in all regions and throughout the year (SANTOS, 2001; SOARES; VIEIRA, 1998; SILVA et al., 2009).

This insect pest inhabits all cotton-producing regions. It is particularly prevalent where cotton is rotated with wheat, oats or maize or is grown close to maize-producing areas (DEGRANDE, 1998). It has caused considerable damage to cotton plants in many areas of Brazil, in particular, in the Brazilian Savanna (Cerrado) where the climate is favorable, there is excessive and inappropriate spraying of insecticides and the schedule of crop rotation favors the increase of armyworm populations (SOARES; ARAÚJO, 2001).

The fall armyworm causes damage at all stages in the development of cotton plants, from seedlings to the ripening of the fruits (ALI et al., 1989; GALLO et al., 2002; SANTOS, 2001). The larvae cut young plants at the stem base and thereby reduce the standing crop (ALI et al., 1989; SANTOS, 2001; GALLO et al., 2002). In more mature plants, larvae select the non-lignified upper part of the stem; scrape off the epidermis of the bracts, the squares, the blooms, the bolls (SANTOS, 2001) and the apical shoot meristems, penetrate and damage squares, blooms and developed bolls (ALI et al., 1989; GALLO et al., 2002); destroy leaves; and penetrate the stems when there are no bolls (ALI et al., 1989; GALLO et al., 2002). The penetration of bolls by the fall armyworm causes a reduction in the quantity and quality of fiber and increases the susceptibility to disease of these reproductive organs under different climatic conditions. High economic losses result from these damaging effects (LUTTRELL; MINK, 1999).

The high levels of damage caused by the fall armyworm to cotton plants in Brazil the economic importance of the crop (SOARES; VIEIRA, 1998), the use of chemical insecticides as the only control measure (VALICENTE; FONSECA, 2004) and the scarcity of data regarding new control tactics justify studies of the feeding habits of the fall armyworm on cotton plants. These studies can potentially with a possible contribute to the optimization of measures for the management of this pest.

The aim of this work was to evaluate the attractiveness of different cotton plant parts and varieties to newly hatched fall armyworm larvae and the non-preference of the larvae for feeding on these plant parts and cotton varieties.

Material and methods

The studies reported in this paper were performed non-in the Entomology Laboratory of the Phytosanitary, Rural Engineering and Soils Department of the Engineering School (UNESP), Ilha Solteira, São Paulo State, in 2007.

Fall armyworms were obtained from the National Maize and Sorghum Research Center (CNPMS – EMBRAPA) located in Sete Lagoas, Minas Gerais. They were reared and maintained in the laboratory on an artificial diet (KASTEN JR. et al., 1978). The breeding methodology described by Parra (1986) was used. The breeding conditions were a temperature of 27 ± 1ºC, a relative humidity of 70 ± 10% and a photoperiod of 14h.

Attractiveness trials and multiple-choice and confinement (no-choice) non-preference feeding trials for parts of the plants (leaves, bracts (2.0 x 1.0 cm), squares and 2-cm carpel walls of bolls) were using the BRS Itamarati-90 cotton variety. The preferred part of the plant identified in these initial trials was then used to differentiate between cotton varieties in subsequent tests of attractiveness and non-preference for feeding. The following varieties were utilized in this trial: Fibermax-966, Fibermax-977, DeltaOpal, DeltaPenta, BRS Acala-90, Coodetec-408, Coodetec-409, Coodetec-410, BRS-Cedro, BRS-Ipê, BRS-Aroeira, IPR-96, IPR-120, BRS-Araçá, IAC-24 and BRS Itamarati 90.

Attractiveness was defined as the capacity of different parts of the plant or cotton varieties to attract newly hatched fall armyworm larvae within 60 min. of their release. Non-preference was defined as the capacity of parts of the plant and plant varieties to remain relatively uneaten up to 24h after release. The non-preference capacity of a plant part was therefore deemed to be relatively greater if a relatively small number of larvae were found to be feeding on that part 24h after the release of the larvae.

In the laboratory, the selected plant parts (leaves, bolls, squares and bracts) were rinsed in distilled water to eliminate contaminants. Excess water was removed using paper towels. Two-centimeter leaf discs, sections of the carpel walls of bolls and bracts (2.0 x 1.0 cm), and entire squares were utilized.

Attractiveness of parts of the cotton plant to fall armyworm larvae

The leaf discs, the sections of the carpel wall of bolls and bracts, and the entire squares were placed equidistant on damp filter paper in a 9 cm-diameter petri dish (2.0 cm high) in a feeding choice arena system. Twenty newly hatched larvae were released in each of ten replications. The total numbers of larvae attracted by the different parts of the plant were counted at 5, 10, 20, 25, 30 and 60 min. after release.

Non-preference for feeding of fall armyworm larvae on different parts of the cotton plant in multiple-choice and confinement (no-choice) feeding trials

In the multiple-choice feeding trial, the procedures and material utilized were the same as for the attractiveness trial. In the no-choice trial, only one part of the plant was placed on damp filter paper in each 6 cm-diameter petri dish (2.0 cm high). For each of 10 replications, twenty newly hatched larvae were released into the petri dishes. The total number of larvae feeding on the parts of the plants 24h after release was used for the evaluation.

Attractiveness of different cotton varieties to fall armyworm larvae

In the arena system, 20 newly hatched larvae were released for each of ten replications. Leaf discs of the different cotton varieties were placed in 20 cm-diameter petri dishes (3.0 cm high) on damp filter paper. The total number of larvae attracted to each leaf disc at 5, 10, 15, 20, 30 and 60 min. after release was used to evaluate attractiveness.

Non-preference for feeding of fall armyworm larvae on different cotton varieties in multiple-choice and confinement (no-choice) feeding trials

In the multiple-choice feeding trial, the procedures were the same as those adopted for the attractiveness trial. In the no-choice feeding trial, each variety was placed on damp filter paper in one 6 cm-diameter petri dish (2.0 cm high). For each of ten replications, twenty newly hatched larvae were released into the petri dishes. The total number of larvae feeding on the leaf discs 24h after release was used for the evaluation.

Experimental design and statistical analysis

A randomized block design with plots subdivided over time was utilized for the attractiveness trials. Additionally, a randomized block design was employed for the non-preference multiple-choice feeding trials. However, a completely randomized design was utilized for the non-preference no-choice feeding trials. The data were analyzed with the analysis of variance procedure. The means were compared using the Tukey test. Polynomial regression was used to analyze the data on attractiveness as a function of time.

Results and discussion

In the multiple-choice feeding trial, the different parts of the BRS Itamarati-90 cotton plant showed significant differences in attractiveness ($F = 18.28$; $p < 0.05$). The leaves and bracts were the most attractive parts. Next in attractiveness were the carpel wall of the bolls and the squares (Table 1). The high attractiveness of leaves and bracts was apparent from the 5th minute after presentation, and this pattern continued throughout the trial. The results of the trial showed that the leaves and the bracts were adequate for evaluating the attractiveness of cotton plants to fall armyworms. These plant parts were therefore selected for use in the subsequent tests.

Table 1. Mean number of newly hatched *Spodoptera frugiperda* larvae attracted to the different parts of cotton plants in different periods after infestation in the feeding choice arena trial.

Part of plant	Time (min.)						
	5	10	15	20	25	30	60
Squares	2.60 c	2.80 b	2.40 b	3.10 b	2.40 c	2.50 c	2.10 c
Bracts	9.30 ab	11.10 a	11.60 a	12.80 a	13.60 a	15.80 a	15.30 a
Leaves	10.20 a	12.30 a	12.60 a	12.20 a	11.80 ab	13.60 a	16.00 a
Carpel walls of the bolls	4.50 bc	5.80 b	6.00 b	6.30 b	6.90 b	6.90 b	8.60 b

Interaction of parts of the plant x time: F = 2.5**, standard error: 0.21. Means followed by the same letter in the same column do not differ significantly (Tukey test, p = 0.05). Original data. For analysis, the data were transformed by $(x + 0.5)^{1/2}$. **Significant at p = 0.01.

For the leaves, bracts and carpel walls of the bolls, the numbers of larvae increased at each time interval after release until the end of the evaluation. However, fewer larvae fed on squares, and the number of larvae feeding varied less over time (Figure 1; $F = 2.5$; $p < 0.05$). By using the formula $y = -0.000579x^2 + 0.0548x + 2.729$ derived from a polynomial regression analysis of the attractiveness data, a period of 46 min. was found to be sufficient to evaluate the attractiveness of different parts of cotton plants to newly hatched fall armyworm larvae.

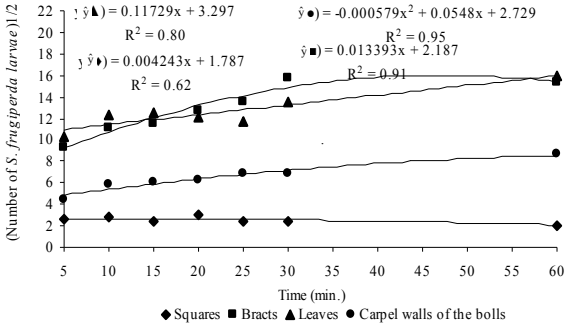

Figure 1. The relationship between the time after infestation and the number of newly hatched *Spodoptera frugiperda* larvae attracted to the different parts of cotton plants in the feeding choice arena trial.

The feeding preferences of the fall armyworm larvae for different parts of the BRS Itamarati-90 variety differed significantly (Figure 2; choice, $F = 22.60$; $p < 0.05$ and no-choice, $F = 9.50$; $p < 0.05$). In the multiple-choice feeding trial, the leaves were the preferred part of the plant, whereas in the

confinement feeding trial, the preferences shown by the larvae for the leaves and for the bolls did not differ significantly (Figure 2). These results are similar to those found in previously published studies in which newly hatched larvae preferred feeding on leaves (ALI et al., 1990), followed by bracts (FREEMAN, 1999; PEREIRA, 1971) and bolls, which were penetrated by irregularly shaped holes (PEREIRA, 1971). Similar results were obtained by Ali et al. (1990), who reported that newly hatched larvae preferred to feed on leaves under both field conditions and in a shade house.

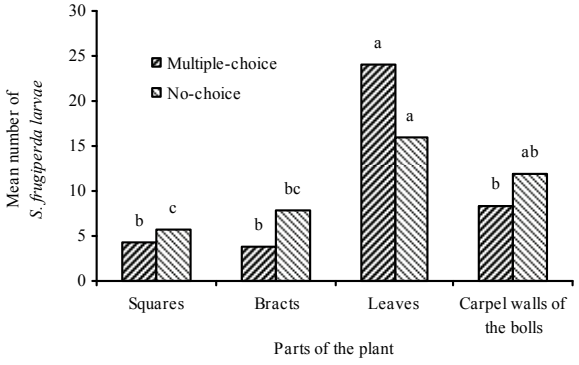

Figure 2. Mean number of newly hatched *Spodoptera frugiperda* larvae on the different parts of cotton plants of the variety BRS Itamarati-90 in feeding multiple-choice and no-choice preference trials.

Significant differences in attractiveness ($F = 3.41$; $p < 0.05$) were observed for the different cotton varieties in the multiple-choice feeding arena trial (Table 2). Coodetec-410 proved to be significantly more attractive to larvae, whereas DeltaPenta, BRS Acala-90 and Fibermax-966 were the least attractive (Table 2). From 5 to 60 min. after release, the numbers of larvae feeding on the varieties Coodetec-410, Coodetec-408, BRS-Ipê and BRS-Cedro (Figure 3) increased. These varieties were the most attractive (the numbers of larvae feeding on them were higher) (Table 2).

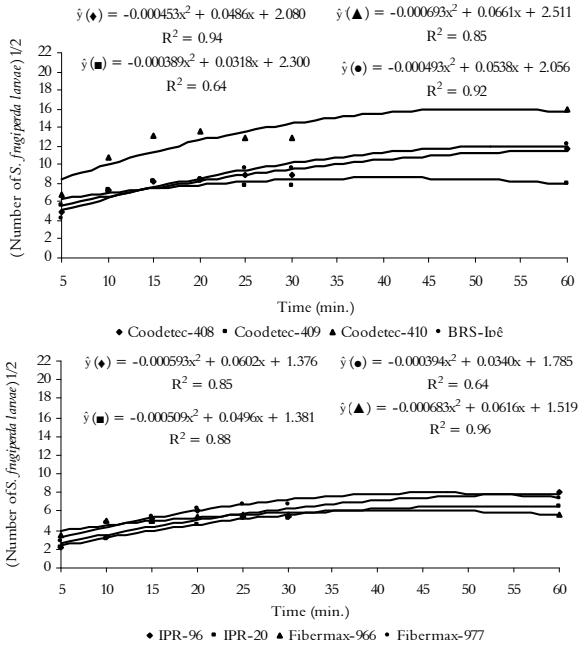

Figure 3. Relationship between the time after infestation and the number of newly hatched *Spodoptera frugiperda* larvae attracted to different cotton varieties in the feeding choice arena trial.

The varieties BRS Acala-90, Fibermax-966 and DeltaPenta were less attractive. The numbers of feeding larvae were smaller and varied less (Figure 4). In the trials on the attractiveness of cotton plants to larvae ($F = 1.68$; $p < 0.05$), the polynomial regression equation showed that 46 min. was a sufficient amount of time to evaluate the feeding pattern of the larvae on cotton varieties. After this period, the number of feeding larvae on each variety decreased (Figures 3 and 4).

Table 2. Mean number of newly hatched *Spodoptera frugiperda* larvae attracted to different cotton varieties in different periods after infestation in the feeding choice arena trial.

Varieties	Time (min.)						
	5	10	15	20	25	30	60
IPR-96	2.20 ab	3.20 c	5.30 b	6.10 b	5.40 ab	6.00 b	8.00 bcd
IPR-120	2.10 ab	3.00 c	4.70 b	4.60 b	5.20 b	4.70 b	6.50 bcd
Fibermax-966	3.50 ab	5.10 abc	5.10 b	5.40 b	5.60 b	5.40 b	5.70 cd
Fibermax-977	2.80 ab	4.80 abc	5.40 b	6.30 b	6.80 ab	7.10 ab	7.50 bcd
Coodetec-408	4.80 ab	7.20 abc	8.20 ab	8.50 ab	8.80 ab	9.70 ab	11.70 abc
Coodetec-409	5.70 ab	7.20 abc	8.20 ab	8.30 ab	7.80 ab	7.80 ab	8.00 bcd
Coodetec-410	6.80 a	10.80 a	13.20 a	13.60 a	12.90 a	14.00 a	15.90 a
BRS-Ipê	4.30 ab	7.00 abc	8.30 ab	8.40 ab	9.50 ab	9.20 ab	12.10 ab
BRS-Aroeira	3.70 ab	8.40 ab	8.10 ab	9.40 ab	9.90 ab	10.10 ab	9.90 abcd
BRS-Araçá	3.70 ab	7.00 abc	8.00 ab	8.00 ab	8.30 ab	10.00 ab	10.80 abcd
BRS-Cedro	4.00 ab	6.00 abc	6.70 ab	8.90 ab	7.90 ab	9.00 ab	10.70 abcd
BRS Itamarati-90	3.60 ab	5.90 abc	7.70 ab	7.30 ab	8.90 ab	9.40 ab	9.80 abcd
DeltaPenta	3.00 ab	5.50 abc	7.20 ab	5.70 b	6.20 ab	5.30 b	5.10 d
DeltaOpal	2.20 b	4.40 bc	5.80 b	5.90 b	6.90 ab	7.60 ab	8.90 abcd
BRS Acala-90	2.60 ab	4.80 abc	5.50 b	5.20 b	5.10 b	5.20 b	4.80 d
IAC 24	2.80 ab	4.80 abc	5.70 b	6.90 ab	6.90 ab	6.30 b	7.90 bcd

Interaction of varieties x time: F = 1.68**, standard error: 0.91. Means followed by the same letter in the same column do not differ significantly (Tukey test, p = 0.05). Original data. Data were transformed by $(x + 0.5)^{1/2}$ for analysis. **Significant at p = 0.01.

Significant differences in the feeding non-preference of the larvae were observed for the different cotton varieties in the multiple-choice feeding arena (Figure 5; $F = 2.53$; $p < 0.05$). A larger number of larvae fed on BRS-Araçá. This variety was therefore the favored variety. Coodetec-408, BRS-Aroeira, BRS-Cedro, BRS Itamarati-90 and DeltaPenta were the least-preferred varieties (Figure 5). No significant difference was observed in respect to non-preference for feeding of newly-hatched fall armyworm larvae between the different cotton varieties in the no-choice feeding trial (Figure 5; $F = 1.36$; $p > 0.05$).

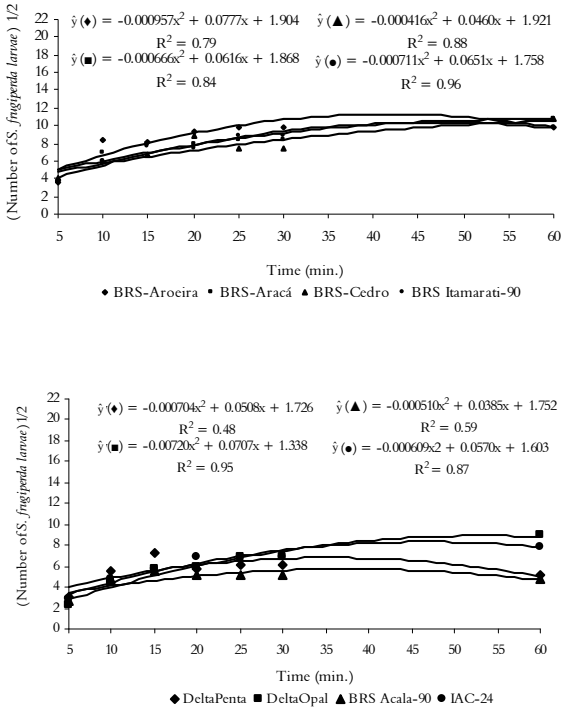

Figure 4. Relationship between the time after infestation and the number of newly hatched *Spodoptera frugiperda* larvae attracted to different cotton varieties in the feeding choice arena trial.

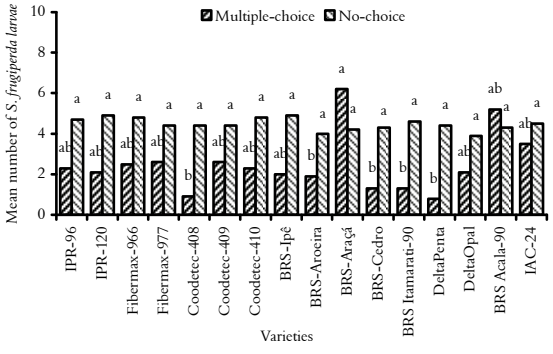

Figure 5. Mean number of newly hatched *Spodoptera frugiperda* larvae on different cotton varieties in feeding multiple-choice and no-choice preference trials.

Conclusion

In general, the leaves proved to be the most suitable part of the plant with which to study the attractiveness and non-preference for feeding on cotton plants in newly hatched fall armyworm larvae. Among the different varieties assessed, BRS Acala-90, Fibermax-966 and DeltaPenta were the least attractive, whereas DeltaPenta was the least preferred for feeding in the feeding choice arena trial. Under laboratory conditions, it was observed that 46 min after the beginning of the attractiveness trial was the best time at which to evaluate the attractiveness of the varieties of cotton plants to newly hatched larvae of this insect pest.

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