Brazilian Journal of Biology®

ISSN 1519-6984 (Print)
ISSN 1678-4375 (Online)

Original Article

Monitoring cotton squares with opened and/or yellowed bracts to determine the need and efficency of chemical control against the cotton boll weevil

Monitoramento de botões florais com brácteas abertas e/ou amarelecidas para determinar a necessidade e eficiência do controle químico contra o bicudo-do-algodoeiro

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Abstract

The technique of terrestrial sampling of boll weevil (BW) populations is expensive and inefficient over large areas, but may be cheaper and more efficient without involving the manipulation of cotton squares. The aim of this study was to develop a technique to sampling cotton squares based on the observation of opened and/or yellowing bracts to determine the need and efficacy of chemical control of BW in cotton crops. The first experiment aimed to estimate the ratio between the number of cotton squares with opened and/or yellowed bracts and that of squares with BW oviposition punctures. The second experiment, aimed to determine the efficacy of chemical control for BW by sampling cotton squares with opened and/or yellowed bracts. The ratio between the number of opened and/or yellowed bracts and the number of cotton squares with oviposition punctures was 2:1. The level and efficiency of chemical control of BW, based on the percentage and sampling of cotton plants with opened and/or yellowed bracts, was 5% and did not differ from the one based on the observation of cotton plants with 10% cotton squares with oviposition punctures by BW females. The control level based on sampling cotton plants with open and/or yellowing bracts was 5%. The efficiency of chemical insecticides using this economic threshold against the BW did not differ from that based on sampling cotton plants with 10% of cotton squares with oviposition punctures by BW females. This indicates that the chemical control of cotton boll weevil can be carried out based on cotton squares with open and/or yellowed bracts.

Keywords: *Anthonomus grandis*, control threshold, cotton pest, pest sampling.

Resumo

A técnica de amostragem terrestre de populações do bicudo-do-algodoeiro é cara e ineficiente em grandes áreas, mas pode ser mais barata e mais eficiente sem envolver a manipulação dos botões florais de algodoeiros. O objetivo deste estudo foi desenvolver uma técnica de amostragem de botões florais de algodoeiros, baseada na observação de brácteas abertas e/ou amarelecidas, para determinar a necessidade de controle químico do bicudo em lavouras de algodão. O primeiro experimento teve por objetivo estimar a razão entre o número de botões florais de algodoeiros com brácteas abertas e/ou amarelecidas e o daqueles com orifícios de oviposição. O segundo experimento teve por objetivo determinar a eficiência do controle químico do bicudo por meio da amostragem de botões florais de algodoeiros com brácteas abertas e/ou amarelecidas. A razão entre o número de brácteas abertas e/ou amarelecidas e o de botões florais de algodoeiros com orifícios de oviposição foi de 2:1. O nível de controle, baseado na amostragem de algodoeiro com brácteas abertas e/ou amarelecidas, foi de 5%. A eficiência do inseticida químico utilizando esse limiar econômico contra o bicudo não diferiu daquela baseada na amostragem de plantas de algodão com 10% de botões florais com orifícios de oviposição por fêmeas desse inseto. O controle químico do bicudo-do-algodoeiro pode ser realizado a partir de amostragens de brácteas abertas e/ou amarelecias em plantas de algodoeiro.

Palavras-chave: *Anthonomus grandis*, amostragem de pragas, limiar de controle, praga de algodão.

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Received: January 12, 2024 – Accepted: April 3, 2024

1. Introduction

Cotton (*Gossypium hirsutum* L.) is an important cash crop in about 70 countries with annual production estimated at 67 million tons (Zeng et al., 2018). Brazil produced 4.37 million tons of cotton in the 2023/2024 harvest over an area of 1.75 million hectares, making it the third producer and the second-largest global exporter of cotton (Brasil, 2023). Pests and diseases reduce cotton production between 15–20% and up to 50% in some years (Chi et al., 2021).

The cotton boll weevil (BW), *Anthonomus grandis* grandis Boheman (Coleoptera: Curculionidae), demands the most attention due to the serious damage it causes to the Brazilian cotton crop (Ramalho, 1994; Silva et al., 2020). This insect, with high reproduction and three to seven generations per crop, destroys the reproductive structures and modifies the plant vegetative development, besides compromising cotton fiber production and quality (Alves et al., 2021).

BW management depends on evaluating the spatial and temporal distribution of populations of this insect with periodic sampling to define chemical insecticide applications (Oliveira et al., 2022). However, BW terrestrial sampling by manipulating and observing a medium-sized cotton square (4-6 mm in diameter) in the upper third of the plant crown with feeding and/or oviposition punctures made by this insect is expensive and inefficient over large areas (Luttrell et al., 2015; Severtson et al., 2016; Neves et al., 2018). The bracts protect the cotton squares hiding these lesions, forcing the sampler to manipulate this structure of the plant to observe it.

The bracts open and turn yellow a few days after BW females lay their eggs on the cotton squares and subsequently abort (Greenberg et al., 2003; Paim et al., 2021). Our hypothesis is that the choice for chemical insecticide application against BW in cotton crops, based on sampling of cotton squares with open and/or yellowed bracts, does not differ from the traditional one based on sampling cotton squares with oviposition punctures by this insect.

The objective of this study was to develop a technique to sample cotton squares based on the observation of opened and/or yellowed bracts to determine the need of chemical control of BW in cotton crops.

2. Material and Methods

2.1. Experiment location, soil preparation and fertilization

The study was carried out in an experimental cotton plantation with a history of BW damage in the headquarters of Embrapa Algodão in the municipality of Campina Grande, Paraíba state, Brazil (latitude 7° 13' 50" S and 35° 52' 52" W of longitude) in 2021 and 2022. The soil of these areas is Eutrophic Regolithic Neosol (Santos et al., 2018) and the climate of Campina Grande is Aw with average temperature and annual rainfall of 22.9 °C and 765 mm, respectively, according to the Köppen and Geiger classification.

Two experiments were developed in plowed and harrowed soil. Fertilization was applied according to soil analysis and technical recommendations for the crop (Vieira et al., 2018). The fertilizers used were: urea (45% N), phosphorus pentoxide (18% P_2O_5) and potassium chloride (60% K_2O) as N-P-K sources (Fertilizantes Heringer SA, Paulínia, São Paulo, Brazil), respectively. The first experiment aimed to estimate the ratio between the number of cotton squares with opened and/or yellowed bracts (Figure 1) and that of cotton squares with BW oviposition punctures. The second experiment determined whether the need and effeciency of chemical control of BW, based on sampling cotton squares with opened and/or yellowed bracts, is similar to that of traditional one based on cotton squares with BW oviposition punctures.

2.2. Ratio of cotton squares with BW oviposition punctures and the number of opened and/or yellowed bracts

BRS 433 B2RF (transgenic cotton cultivar), obtained from the active germplasm bank (AGB) of Embrapa Algodão was sown manually on April 4, 2021 in the experimental field of this institution. Sucking insects and mites were controlled with sprays of neem oil 1000 CE (Natuneem®) at 1ml/100ml and abamectin (Vertimec 18 CE®) at 7.2 g.i.a. ha^{-1}, respectively, where necessary.

The percentage of cotton squares with BW oviposition punctures with opened and/or yellowed bracts, estimated for the control level over an area of 531.2 m^2 (16.6 m × 32 m), was 10% (Alves et al., 2021).

The experimental design was in randomized blocks with two treatments and 12 replications (blocks). Each parcel, two meters long, had eight rows of cotton plants with approximately 160 plants each one spaced 0.80 m × 0.10 m between rows and plants, respectively. The distances between plots and blocks were 4 m.

Twenty plants were randomly sampled per parcel every five days. Free-living BW adults were not included in the sampling because their numbers were low and without representative damage to the cotton plants (Oliveira et al., 2022).

Sampling started when the cotton plants produced the first cotton square and continued until none was observed for oviposition by BW females, which prefer infesting them (Greenberg et al., 2005).

Medium-sized cotton squares (4-6 mm in diameter) with oviposition punctures (1) and those with opened and/or yellowed bracts in the upper third of the canopy of the plants sampled (2) were visually observed.

2.3. Determining the efficiency of chemical control of BW based on sampling cotton squares with opened and/or yellowed bracts

Seeds of the cotton BRS 433 2RF were manually planted on December 23, 2021 in the experimental field of Embrapa Algodão. Sucking insects and mites were controlled as described earlier.

The efficiency of chemical control of BW, based on sampling cotton squares with opened and/or yellowed bracts, was determined in an area of 768 m^2 (24 m × 32 m). The experimental design was in randomized blocks, with four treatments and four replications (blocks).

The treatments consisted of cotton plants sprayed with malathion (Malathion 1000 EC, emulsifiable concentrate,

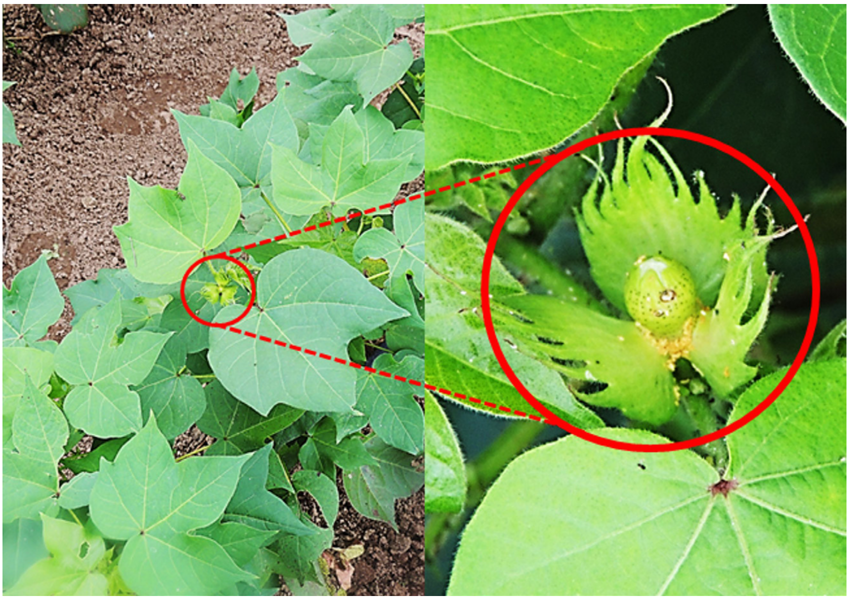

Figure 1. Captured RGB images of a cotton square with opened and yellowed bracts in the canopy of a cotton plant. Campina Grande, Paraíba state, Brazil, 2022.

FMC, Uberaba, Minas Gerais, Brazil) as follows: weekly (1,000 g.i.a. L-1) after finding cotton squares (T1); when the number of plants with cotton squares presenting oviposition punctures reached 10% (Silva et al., 2013; Alves et al., 2021) (T2); or when the plants with cotton squares with opened and/or yellowed bracts reached 5% (percentage of open bracts corresponding to the cotton squares with oviposition punctures determined in the first experiment) (T3) and the control (without spraying) (T4).

The organophosphate insecticide malathion was employed because it is cheap, highly effective and most used by Brazilian cotton growers to control BW (Rolim et al., 2019). The parcel contained five-meter-long cotton plant rows, with approximately 250 plants spaced 0.80 m × 0.10 m between rows and plants, respectively. The distance between parcels and blocks was four and four meters, respectively. The spraying against BW was carried out using a manual backpack sprayer with capacity for 20 L of syrup and empty cone type D2 nozzle. The spray nozzle was positioned, laterally, in relation to the cotton rows about 20 cm from the plants with flow adjusted according to the growth stage of the plants, with 150 to 300 L of water solution·ha^{-1} (Alves et al., 2021).

A medium-sized cotton square (4-6 mm in diameter) from the upper third of the canopy of each cotton plant was sampled randomly and the presence or absence of oviposition punctures was recorded. In the third treatment, the number of opened and/or yellowed bracts (2) per plant was recorded. The evaluations were performed every five days, randomly sampling 30 plants per parcel. Standard cultivation procedures for crop management (application of pesticides, manual weeding, etc.) were performed as required.

The number of cotton squares with oviposition punctures and those with opened and/or yellowed bracts at different sampling periods, mean percentages of damaged cotton squares and those with oviposition punctures by BW females, plant height and cottonseed production were determined by sampling 30 plants per parcel. Cotton production was estimated by manually harvesting and weighing the cotton from each seeded plant with bolls from ≅150 plants sampled per parcel.

2.4. Data analysis

A linear regression was generated, and its points submitted to correlation analysis using the Pearson® method at 5% probability to obtain the number of cotton squares with oviposition punctures by BW females in relation to those with opened and/or yellowed bracts. Logarithmic regression curves, representing the number of cotton squares with oviposition punctures and those with opened and/or yellowed bracts were generated to calculate the ratio between them. Another logarithmic regression curve was generated by multiplying each point of the logarithmic regression curve of the number of opened and/or yellowed bracts by the estimated proportion, to confirm the overlapping of this curve over the one representing the number of cotton squares with oviposition punctures.

Data of the number of cotton squares with oviposition punctures, opened and/or yellowed bracts (x2) and plant age with the percentage of cotton squares with oviposition punctures from BW females were subjected to two-way analysis of variance (ANOVA) and its means compared using the Tukey's test at 5%. The effects of malathion spraying on the number and percentage of cotton squares with oviposition puncture damage by BW females and plant height and seed cotton production (g) were also subjected to the same type of analysis of variance and means comparison.

The measurements of each experimental unit was used in the analyses. The proportion of squares oviposition-punctured by boll weevils in experiments with 1 was transformed into arcsine square root before repeated measure analysis; however, untransformed means are presented. The data from the three experiments were analyzed using the Statistical and Genetic Analysis System (SAEG) of the Federal University of Viçosa.

3. Results

The average temperature, relative humidity and monthly rainfall in the Embrapa Algodão experimental field during the first and second experiments in 2021 and 2022 were 23 ± 1 °C, 83 ± 1% and 65 mm, and 24 ± 1 °C, 83 ± 2% and 111 mm, respectively (INMET, 2021).

3.1. Ratio of cotton squares with opened and/or yellowed bracts with those with oviposition punctures

The cotton phenologic cycle lasted 150 days, with plant emergence, the appearance of the first cotton squares and boll opening at 10, 45 and 95 days after planting, respectively. Sucking insects and mites were not found in the experimental area and, therefore, insecticides and acaricides were not applied.

The number of cotton squares with opened and/or yellowed bracts, equivalent to those with BW oviposition punctures ($y = 0.6178x - 0.3279$, $R^2 = 0.88$) (Figure 2) was positively correlated (tcal = 7.22, R = 0.94, $P < 0.001$) and best represented by the linear model.

The number of cotton squares with oviposition punctures ($y1 = 2.9402 \ln(x) - 9.6219$, $R^2 = 0.80$) and those with opened and/or yellowed bracts ($y2 = 2.0097\ln(x) - 7.0803$, $R^2 = 0.86$) due to damage by the BW, as a function of plant age, were best represented by logarithmic regression curves (Figure 3A). The ratio between the number of cotton squares with oviposition punctures and the number of opened and/or yellowed bracts was 2:1 with the points of the logarithmic regression curve representing that of opened and/or yellowed bracts multiplied by 2 ($y2 = 4.0167\ln(x) - 14.148$, $R^2 = 0.87$) (Figure 3B), similar to that of the cotton squares with oviposition punctures ($y1 = 2.9402\ln(x) - 9.6219$, $R^2 = 0.80$).

Plant age and interaction between treatments (plant sampling based on cotton squares with oviposition punctures or opened and/or yellowed bracts x 2) and plant age ($P < 0.01$ for both, Table 1) and the percentages of cotton squares with oviposition punctures by BW, but not of treatments, were significant by the two-way analysis of variance ($P > 0.05$, Table 1). The percentages of cotton plants with cotton squares with BW oviposition punctures were lower and higher, respectively, at 40 and 89-90 days of age than those sampled based on cotton squares with oviposition punctures and with opened and/or yellowed bracts (x2) (Table 2). The percentages of cotton plants with cotton squares with oviposition punctures or opened and/or yellowed bracts were similar between treatments (x2).

3.2. Efficiency of chemical control of BW based on sampling cotton squares with opened and/or yellowed bracts

The phenological cycle of the cotton plant lasted 180 days, with the emergence of cotton plants, the appearance of the first cotton square and the opening of the bolls at 12, 60 and 110 days after planting, respectively.

The interaction between treatment and plant age ($P < 0.001$ for all; Table 3) with the number of plants with cotton squares presenting BW oviposition punctures was

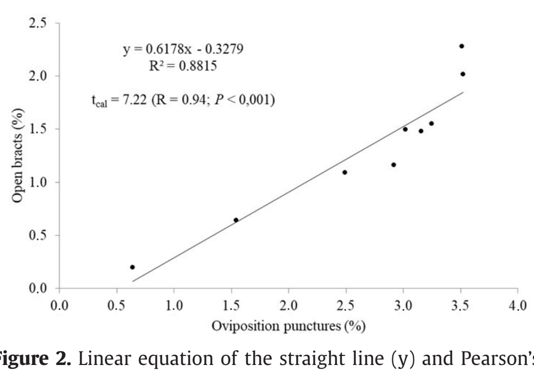

Figure 2. Linear equation of the straight line (y) and Pearson's correlation (t_{cal}) between the number of cotton squares with opened bracts and that with oviposition punctures by cotton boll weevil females.

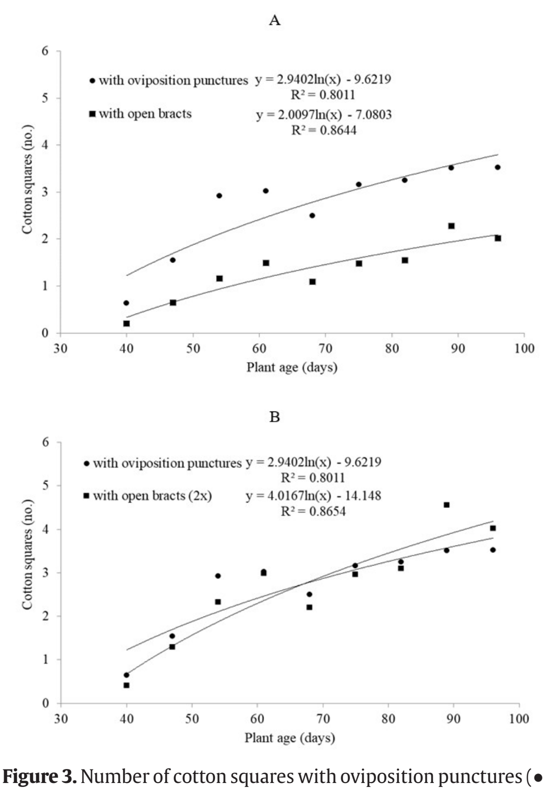

Figure 3. Number of cotton squares with oviposition punctures (●) and opened bracts (■) per plant age (A) and graphical representation after multiplying each point of the logarithmic regression curve, which represents the number of opened bracts and/or yellowed, by the equivalent of cotton squares with oviposition punctures (B).

Table 1. Two-way analysis of variance (ANOVA) summary model for the effects of treatment and plant age on the percentage of cotton plants with cotton squares with boll weevil oviposition punctures in the parcels.

Source of variation	Models	DF	Mean Square	*F*	*P*
Plant with oviposition punctures	Treatment (T)	1	0.272119	0.475	> 0.05
	Plant age (PA)	8	37.49382	65.430	< 0.01
	T × PA	8	4.464990	7.792	< 0.01
	Residues	198	0.573040	-	-

Treatments: (T1) cotton squares, with oviposition punctures by the boll weevil, sampled every five days after the appearance of the first cotton squares on the cotton plant; (T2) cotton squares with bracts opened equivalent to cotton squares with boll weevil oviposition punctures sampled every five days after the appearance of the first cotton squares; DF = degrees of freedom.

Table 2. Percentage (mean ± SE) of cotton squares with oviposition punctures and bracts opened equivalent (x2) to that of cotton squares with oviposition punctures by cotton boll weevil by plant age (age) in cotton parcels.

Age (days)	Treatments	
	Oviposition punctures	Opened bracts
40	0.63 ± 0.00 d A	0.40 ± 0.00 e A
47	1.57 ± 0.00 cd A	1.29 ± 0.00 de A
54	3.07 ± 0.00 abc A	2.32 ± 0.00 bcd B
61	3.37 ± 0.00 abc A	2.99 ± 0.00 bc A
68	2.49 ± 0.00 bcd A	1.97 ± 0.00 cde A
75	3.06 ± 0.00 abc A	2.94 ± 0.00 bc A
82	3.26 ± 0.00 abc A	3.10 ± 0.00 bc A
89	3.53 ± 0.00 ab A	3.32 ± 0.00 a A
96	3.61 ± 0.00 ab A	4.89 ± 0.00 a A

Means followed by the same lowercase letter in the column and uppercase in the line do not differ by Tukey's test at 5% probability. Data transformed into arcsine square root for statistical analysis. Original means are shown.

Table 3. Two-way summary analysis of variance (ANOVA) model for the effects of treatment and plant age on the number of cotton plants with cotton squares with boll weevil oviposition punctures in the parcels.

Source of variation	Models	DF	Mean Square	*F*	*P*
Plant with oviposition punctures	Treatments (T)	3	2744.668	37.055	<0.001
	Plant age (PA)	7	4158.135	56.137	<0.001
	T × PA	21	952.9588	12.866	<0.001
	Residue	96	74.07057	-	-

Treatments: (T1) cotton squares with oviposition punctures by the boll weevil sampled every five days after the appearance of the first cotton squares on the cotton plants; (T2) cotton squares with bracts opened equivalent to cotton squares with oviposition punctures by the boll weevil sampled every five days after the appearance of the first cotton squares on the cotton plants; DF = degrees of freedom.

significant. The numbers of plants with cotton squares with BW oviposition punctures differed between treatments at 95, 125 and 135 days (Table 4). The number of plants with cotton squares presenting oviposition punctures was higher in the control at 95, 125 and 135 days while those with boll weevil infestation reached the economic threshold of 10% of cotton squares with oviposition punctures at 95 days (Table 4). The economic threshold of plants sprayed weekly or when 5% and 10% with opened and/or yellowed bracts of cotton squares with oviposition punctures per treatment sprayed with malathion was reached at 125 and 135 days of plant age. The peaks of cotton squares with oviposition punctures were greater for 115-day-old cotton plants in all treatments sprayed with malathion (Table 4) and in the control in the last evaluation at 135 days of plant age.

The percentage of cotton plants with cotton squares with oviposition punctures ($F_{3,9}$ = 20.93; p < 0.001) and plant height ($F_{3,9}$ = 20.13; p < 0.001) were lower and cotton seed production ($F_{3,9}$ = 31.14; p < 0.001) higher in the treatments sprayed with malathion, weekly, or when the BW reached the economic threshold of 5% and 10% of plants, respectively, for the cotton squares with oviposition punctures and opened and/or yellowed bracts (Figure 4). On the other hand, the percentage of cotton plants with

Table 4. Number of cotton squares with oviposition punctures (average ± SE) of boll weevil in 60 cotton plants per parcel every five days after spraying with malathion (01); malathion from 10% (02) and 5% (03) of cotton squares with bracts opened and/or yellowed (3) and the control (without insecticide spraying) per age (65 to 151 days after emergence). Sampling data is shown in the table every ten days.

Age (days)	Treatments			
	01	02	03	04
65	3.33 ± 0.96 a D	3.75 ± 1.42 a D	2.50 ± 1.60 a C	2.08 ± 1.25 a C
75	12.50 ± 1.51 a CD	13.33 ± 2.64 a BCD	7.54 ± 6.43 a C	2.50 ± 1.08 a C
85	2.92 ± 1.42 a D	7.08 ± 3.62 a D	9.44 ± 3.58 a C	9.58 ± 5.50 a C
95	8.33 ± 3.40 b CD	32.20 ± 7.67 a ABC	4.17 ± 1.60 b C	47.25 ± 13.38 a B
105	23.33 ± 4.76 a BCD	26.66 ± 2.82 a ABCD	30.83 ± 5.83 a AB	19.74 ± 4.06 a C
115	49.17 ± 3.63 a AB	39.17 ± 1.98 a ABC	37.50 ± 5.99 a AB	52.50 ± 3.23 a B
125	42.08 ± 1.58 b ABC	30.83± 1.73 b ABCD	28.33 ± 3.97 b ABC	78.75 ± 4.10 a A
135	7.50 ± 0.83 b CD	10.00 ± 2.04 b CD	10.00 ± 2.72 b BC	80.83 ± 0.83 a A
151	First opened bolls			

Means followed by the same lowercase letter in the column and uppercase in the line do not differ by Tukey's test at 5% probability.

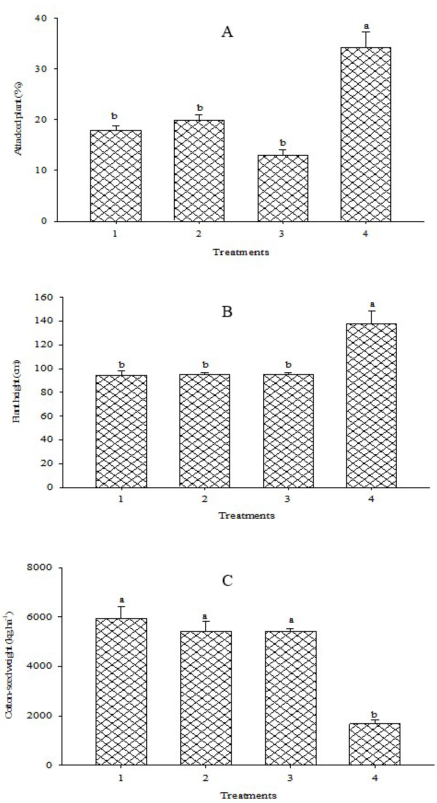

Figure 4. Percentage of plants attacked by boll weevil (A), plant height (B) and cottonseed production (C) in treatments sprayed weekly with malathion (Malathion 1000 EC, 1,000 g.i.a. L^{-1}) after the appearance of cotton squares (1); when the number of plants with cotton squares with oviposition punctures and opened and/or yellowed bracts reached 10% (2) and 5% (3); and in the control (without spraying) (4). Means followed by the same lowercase letter do not differ by Tukey's test (P= 0.05). Data on the percentage of plants damaged were transformed into square root of arcsine for statistical analysis. The original means are shown.

cotton squares presenting oviposition punctures was greater and the height and seed production lower in the control.

4. Discussion

Temperature, relative humidity and weekly precipitation in the Embrapa Algodão experimental field during the first and second experiments were adequate to increase BW populations and did not reduce the bract opening of cotton squares oviposited by BW females (Herzog and Lambert, 1984; Neves et al., 2018; Faustino et al., 2021).

4.1. Number of cotton squares with opened and/or yellowed bracts and those with BW oviposition punctures

The values of the coefficients of determination (R^2) and Pearson's correlation® indicate, respectively, that the percentage of cotton squares with oviposition punctures explains 88% of the opened and/or yellowed bracts. There was a positive, robust correlation between these variables, that is, between the increased number of cotton squares with oviposition punctures and the number of opened and/or yellowed bracts. This was expected, because the bracts open and turn yellow and, subsequently, the cotton plant aborts the squares a few days after oviposition by BW females (Greenberg et al., 2003; Paim et al., 2021).

Parallel and proportional logarithmic regression curves, representing the number of cotton squares with oviposition punctures and the number of opened and/or yellowed bracts due to BW damage, as a function of plant age, indicate that, for each flower bud with an opened and/or yellowish bract, two others have oviposition punctures. These results are similar to the proportion estimated for these variables in fields of the cotton Coker 310 genotype in the municipality of Tift, Georgia, USA treated with diflubenzuron (Herzog and Lambert, 1984). The similar number of cotton squares with oviposition punctures by BW females determined in both treatments (sampling types) indicates that the estimate, using the percentage of cotton squares with opened and/or yellowed bracts, is accurate and equivalent to that of cotton squares with BW oviposition punctures. This method can be used to evaluate the efficacy of insecticides to keep BW damage below 10% (Ramalho et al., 1990). On the other hand, the significant interaction between treatments and plant age indicates that older plants tend, during the cotton bud period, to produce a greater number of cotton squares, which increases BW oviposition in a process dependent on the density of this structure (Greenberg et al., 2003, 2005; Alves et al., 2021) and, consequently, their number with opened and/or yellowed bracts (Greenberg et al., 2003).

4.2. Efficiency of chemical control of BW based on sampling cotton squares with open and/or yellowed bracts

The significant interaction between treatment and plant age and the number of plants with cotton squares presenting BW oviposition punctures can be attributed to the exponential increase in these reproductive structures during the flowering period of cotton plants (Alves et al., 2021). This increases the availability of cotton squares for BW female oviposition as the cotton plants mature (Greenberg et al., 2003, 2005). Thus, the infestation of reproductive structures should increase until the 'cut-out' (end of cotton square production), if insecticide spraying is not carried out to control BW (Showler, 2006; Oliveira et al., 2022). This explains why the mean numbers of cotton squares with oviposition punctures were similar in the last two evaluations between treatments sprayed systematically and weekly with malathion or from the economic damage threshold of 5% and 10% of cotton squares, respectively, with opened and/or yellowed bracts and oviposition punctures.

Greater plant height and lower cottonseed production in the control can be attributed to the higher percentage of plants with cotton squares presenting BW oviposition punctures that are, damaged by this insect. Plants prioritize photosynthesized materials for foliage and biomass production to compensate losses to these reproductive structures (Yang et al., 2001; Poorter et al., 2012; Alves et al., 2021). This also explains the losses in cotton production and the greater vegetative development of these plants, which are leafier but less productive when damaged by BW (Yang et al., 2001). On the other hand, the lower plant height, higher numbers of bolls and seed productivity and lower numbers of oviposition punctures and opened and/or yellowed bracts are due to BW population control with weekly malathion application, or from the economic damage threshold of 5% and 10% of cotton squares, respectively, with opened and/or yellowed bracts and oviposition punctures.

The evaluation of the effectiveness of chemical BW control, based on sampling of cotton squares with opened and/or yellowed bracts or cotton squares with BW oviposition punctures, was similar. This is important because it can facilitate the sampling of BW populations across large areas based on the observation of open and/or yellowed bracts, streamlining the decision-making process for the cotton producer to use chemical control against BW, reducing the consumption of insecticides and, consequently, application costs.

Acknowledgements

To the "Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES)" (Finance Code 001) and the "Better Cotton Initiative (BCI)" for financial support for the Embrapa Algodão project (SEG Code: 20.24.00.007.00.00)" and Dr. Phillip John Villani (University of Melbourne, Australia), professional editor and proofreader and native English speaker, reviewed and edited this article for structure, grammar, Playstation, spelling, word choice, and readability.

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