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Relationship between cotton planting date and two bollworms associated with their natural enemies

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Abstract

Background: Cotton is the most widespread, profitable non-food crop in the world. Egypt is one of the greatest countries in producing cotton (*Gossypium hirsutum* L.) in the world. Many pests attacked cotton which reduced the quality and quantity of the cotton yield such as pink bollworm (*Pectinophora gossypiella*) (Lepidoptera: Gelechiidae) and the spiny bollworm (*Earias insulana*) (Lepidoptera: Noctuidae).

Results: The insect infestation increased significantly by delaying planting date. The fewest numbers of pests attacked cotton recorded in the earliest planting date (March 23rd) with highest weight of cotton yield. The results showed that the mean rates of infestation with pink bollworm were (2.11, 3.5, 2.33 individuals/boll) for March 23rd, April 17th and May 6th, respectively, while the mean rates of infestation with bollworm were (1.60, 2.79, 1.67 individuals/boll) for March 23rd, April 17th and May 6th, respectively.

Conclusion: It was concluded that planting cotton as early as on March 23rd reduces the rate of infestation of *E. insulana* and *P. gossypiella* and increases the population of its natural enemies as well. Then, it is resulting a significant increase in the quality and quantity of the yield of cotton.

Keywords: Cotton, Bollworm, *Earias insulana*, Pink bollworm, *Pectinophora gossypiella*, Natural enemies, Planting date

Background

Cotton (*G. hirsutum* L.) is considered very important production agricultural crops in Egypt. It is infested by many insect pests limiting cotton productivity worldwide such as pink bollworm (*Pectinophora gossypiella*), spiny bollworm (*Earias insulana*) and cotton bollworm (*Helicoverpa armigera*) which caused considerable damage of both quantity and quality (Vonzun et al. 2019).

The effectiveness of planting dates on the insect infestation level and the yield were done by Mona A. Mohamed (2011) and Mohamed et al. (2010). Biological studies for developing lots of the models on cotton bollworm *H. armigera* were carried out in Northern China and the aspects of cotton bollworm *H. armigera* have been simulated (Guo 1998; Wu and Guo 2005).

In Zimbabwe, the heavy losses on the cotton yield are accrued by cotton bollworm (*H. armigera*), red bollworm (*D. castanea*), spiny bollworm (*E. insulana* and *E. biplaga*) and pink bollworm (*P. gossypiella*) year after year (Mapuranga et al. 2015).

Three different cotton planting dates as early, mid-season and late dates were investigated. The pest infestation starts from the 5th week after emergence with 10% boll split. All of planting dates had significant effects on pest infestation. Later planted cotton had higher infestation with aphids, jassids and pink bollworm population than early planted cotton, may be this was due to the lower number of natural enemies. The early planting date resulted in lower incidence of insect pests is recommended. (Mohamed 2011, 2012; Karavina et al. 2012).

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The study of the natural enemies and the insect population on the cotton yield during the period from June to October 2011 resulted that the natural enemies and the insect pests have been dispersed after the 15th of October (Pallini et al. 2006; Ashfaq et al. 2011; Ali et al. 2016).

The effect of nitrogen fertilization and the planting date on cotton bolls and cotton fiber caused the bolls to be opened greatly and reduced the insect infestation for the cotton that was planted on 15th of March than that was planted on 15th of May (Saleem et al. 2014).

The aim of work

The aim of this work is to avoid and reduce those injurious pests infesting bolls of the cotton by changing the planting dates.

Methods

The effect of cotton planting date spiny and pink bollworms

Field experiments were carried out in El Ryad village, Kafer El-Sheekh Governorate during the summer plantation season (2014) and season (2015). Cotton was planted in three different planting dates (March 23rd, April 17th and May 6th). Normal agricultural treatments were applied.

Three treatments of planting dates were tested in a Randomizing Complete Block Design (1/100 feddan/Plots) with three replicates.

For each planting date (March 23rd, April 17th and May 6th), sampling of cotton plants collected after 48 days of planting seeds while associated predators were 5 days later; this procedure was done until the end of the experiment. Hundred bolls were picked randomly per plot every 5 days, and the collected samples were kept in tight closed paper bags and transferred to the laboratory to inspect and count the number of pink bollworm (*P. gossypiella*) and spiny bollworm (*E. insulana*). All bolls (infested and healthy) were collected and weighted to estimate the final yields.

Statistical analysis

Experimental design was a randomized complete block design. Data were subjected to one-way analysis of variance followed by Student–Newman–Keuls test to determine significant differences among mean values at the probability level of 0.05 using the Statistical Package for the Social Sciences (SPSS) 25.0 software program (SPSS 2017).

Results

The effect of cotton planting date spiny and pink bollworms:

As shown in Table 1, planting date affected slightly on the population density of pink bollworm (*P. gossypiella*), spiny bollworm (*E. insulana*) during 2014 and 2015.

Table 1 Effect of cotton planting date on the pest incidence with pink bollworm and spiny bollworm

Pest	Planting date			$LSD_{0.05}$
	23rd of March	17th of April	6th of May	
Pectinophora gossypiella	2.11 b	3.50 a	2.33 b	0.36
Earias insulana	1.60 b	2.79 a	1.67 b	0.22

$L.S.D_{0.05}$ least significant difference at 0.05 level of probability; means accompanied by the same letter in the same row are not significantly different at 0.05 level of probability

Table 2 Infestation percentage of pink bollworm (*P. gossypiella*), spiny bollworm (*E. insulana)* and cotton planting date

Planting date	No. of infested bolls/100 bolls	*Pectinophora gossypiella* percentage (%)	*Earias insulana* percentage (%)
23rd of March	19.00 a	2.11 b	1.60 b
17th of April	18.00 a	3.50 a	2.79 a
6th of May	14.00 b	2.33 b	1.67 b
$LSD_{0.05}$	1.13	0.48	0.37

$L.S.D_{0.05}$ least significant difference at 0.05 level of probability; means accompanied by the same letter in the same column are not significantly different at 0.05 level of probability

Delaying planting date affected on increasing the population density of pink bollworm and cotton bollworm.

Planting cotton plants on March 23rd recorded the lowest significant numbers ($F=50.19$; $P=0.0002$) of pink bollworm (2.11 individuals/boll) and spiny bollworm (1.60 individuals/boll).

On the other hand, the cotton plants that planted on April 17th had significantly ($F=99.09$; $P=0.0000$) the largest number of pink bollworm (3.50 individuals/boll) and spiny bollworm (2.79 individuals/boll). However, planting cotton on May 6th recorded (2.33 individuals/boll) of pink bollworm and (1.67 individuals/boll) of spiny bollworm (Table 2).

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The natural enemies:

Natural enemies considered as the first defense line against insect pest, *Chrysopa carnea*, *Coccinellaundecim punctata* and *Paederus alfieri* were count on cotton plants. Our results revealed that there were significant differences in the total number of natural enemies which was highest in early planting date than the others (Table 3).

Early planting of cotton had the highest total number of natural enemies (760 individuals/season) ($F=50.19$; $P=0.0002$) that decreased the total number of the bollworms to (67 individuals/season), while the total number of natural enemies was (451 individuals/ season) ($F=99.09$; $P=0.0000$) that decreased the total number of the bollworms to (72 individuals/season) in the latest planting date (May 6th) (Tables 3, 4).

These results showed that the cotton yield was increased in the earliest planting date (March 23rd) than the cotton yield in the latest planting date (May 6th). Planting cotton on (March 23rd) produced the highest yield (6.94 quintals/Fadden), while the cotton yield was (3.37 quintals/Fadden) in the latest planting date (May 6th) (Table 4).

Discussion

According to Matthew and Tunstall (1994), there are about 1236 insect species on cotton, though most cause little or no economic damage. Pests that attack reproductive structures cause about 80% of the damage in cotton such as pink bollworm (*P. gossypiella*), spiny bollworm (*E. insulana*) and cotton bollworm (*H. armigera*) (Pedigo 2004). Early cotton planting is important as it increases the probability of setting an acceptable fruit load before key pests infestations reach damaging levels. Also, the crop will mature early enough so that residues are disposed of early. This reduces host-plant support for diapausing pests and contributing to a reduction in the overwintering population of the insect pests (Frisbie et al. 1994).

Earlier planting of cotton reduced the chance of infestation by late season insect pests (Pettigrew 2002; Adams et al. 2013). Also, planting dates and planting pattern are considered important factors for increasing seed cotton yield per unit area (Din et al. 2004; Dong et al. 2006 and Barradas and Lopez-Bellido 2009).

Table 4 Relationship between cotton planting date, natural enemies and pests population with cotton yield

Planting date	Cotton yield (quintals/Fadden)	Total natural enemies/season	Total pest no./ season
23rd of March	6.94 a	760.00 a	67.00 b
17th of April	5.21 b	561.00 b	88.00 a
6th of May	3.37 c	451.00 c	72.00 b
$LSD_{0.05}$	0.46	41.62	6.73

$L.S.D_{0.05}$ least significant difference at 0.05 level of probability; means accompanied by the same letter in the same column are not significantly different at 0.05 level of probability

The high value of clover preceding cotton tempted farmers to delay cotton growing to the beginning of May, instead of the recommended 1st of April growing date. The main question raised in the present study was concerned with the negative effects of delaying cotton planting to May, because previous studies recommended that the best planting date in Egypt should be before mid-March (Shalaby 1998, El-Hariry 1986 and Shafshak et al. 1987).

A number of cultural practices like early planting, crop rotation, use of resistant cultivars, proper fertilizer application and proper plant spacing can reduce the heavy usage of synthetic insecticides (Matthews and Turnstall 1994).

Bollworms are serious economic cotton insect pests that attack the reproductive structures (squares and bolls). In studies by Prasifka et al. (2004), the abundance of the natural enemies were strongly linked to cotton planting dates and to the abundance of pests, with early planted fields hosting larger populations of the predators.

Natural enemies were affected directly or indirectly by many factors such as insecticide applications, planting date and the food sources increasing or decreasing the population. The population dynamics of natural enemies can be regulated by reducing the number of insecticide applications (recommended insecticide) and choosing the suitable planting date.

Table 3 Effect of cotton planting date on natural enemies' fluctuation

Natural enemies	Planting date			$LSD_{0.05}$
	23rd of March	17th of April	6th of May	
Paederus alfieri	27.23 b	27.90 a	28.25 a	0.52
Coccinellaundecim punctata	29.95 a	27.60 c	28.44 b	0.79
Chrysopa carnea	32.50 a	28.65 b	28.06 b	1.52

$L.S.D_{0.05}$ least significant difference at 0.05 level of probability; means accompanied by the same letter in the same row are not significantly different at 0.05 level of probability

The cotton yield increased due to increasing the natural enemies which predating insect pests such as pink bollworm (*P. gossypiella*) and spiny bollworm (*E. insulana*).

Conclusion

Planting date affected significantly on the population density of (cotton, pink) bollworms, some predators and the yield of the cotton increasing or decreasing them significantly. Delaying planting date affected on increasing the population density of pink bollworm and cotton bollworm.

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Authors' contributions
Z. A. Attia, L. Ebada and N. M. Abdelmaksoud designed experiments, carried out the biological experiments, analyzed the data, and wrote the article. All authors read and approved the final manuscript.

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All data generated or analyzed during this study are included in this article.

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Not applicable (this study does not involve human participants, data, tissue).

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Not applicable.

Competing interests
The authors declare that they have no competing interests.

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