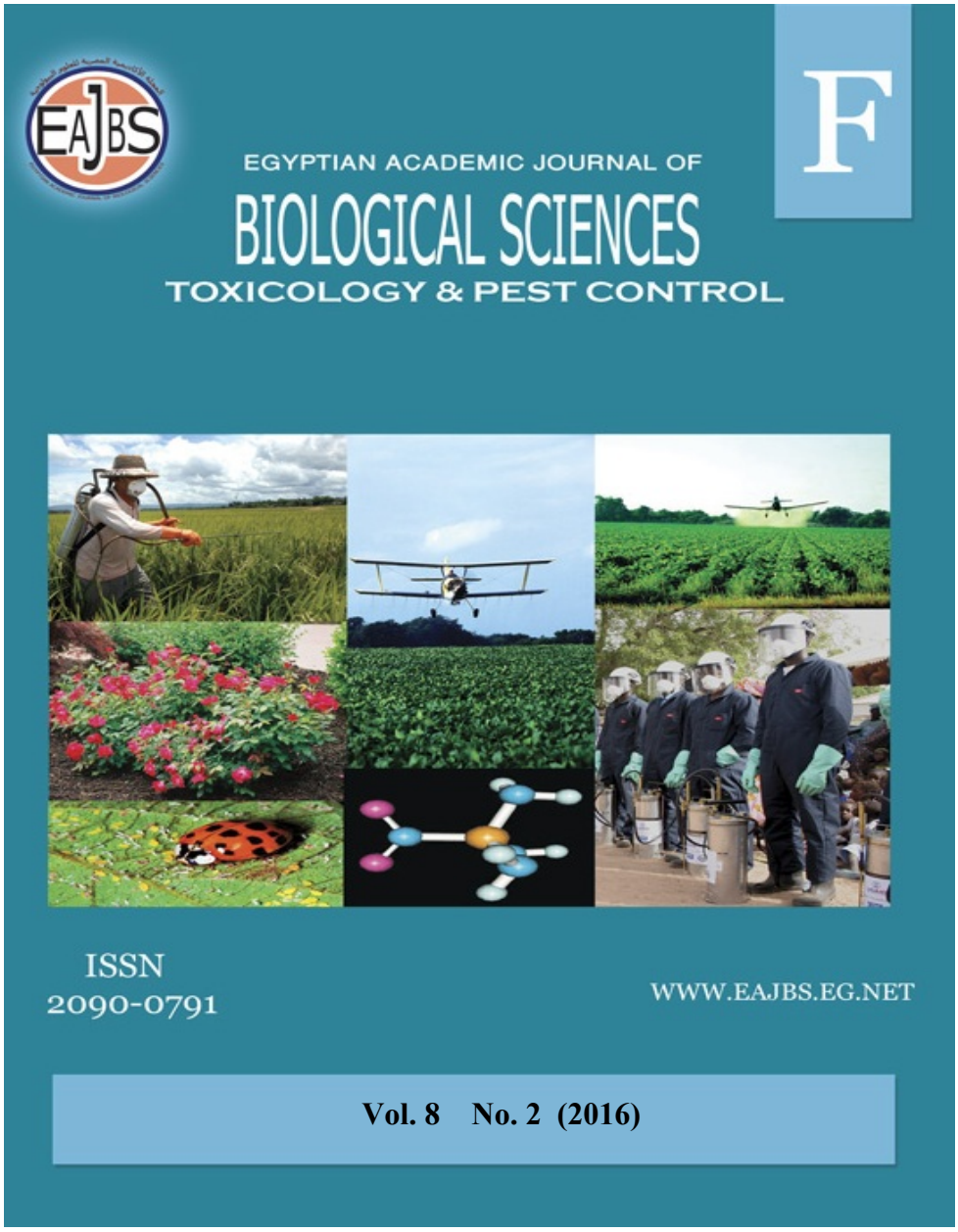

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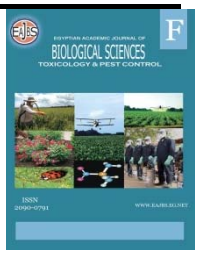

Non-Chemical Control of the Pink Bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) in Cotton Fields at Assuit Governorate, Upper Egypt, I- Using a mating disruption technique

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ABSTRACT

Effect of mating disruption technique, at the rate of 300 PB-Rope dispensers/feddan for suppressing the population and percentage of infestation with the pink bollworm (PBW), *Pectinophora gossypiella* (Saunders) was investigated in cotton fields at Assuit Governorate (Upper Egypt), throughout the two successive cotton growing seasons 2013-2014. Catches of PBW moths in the sex pheromone traps and the damage in green bolls were recorded in both treated and control fields. Data showed that moth catches were highly suppressed (near 100%) in the treated field by installation of the dispensers during the 50% flowering growth stage. In addition, % of average infestation in the cotton green bolls was significantly decreased in the treated (١.٥١&٠.٨٩) compared with the control field (20.54 &12.33%) in both seasons, respectively. A significant difference was found in the average yield/feddan estimated at the plot treated with pheromones (10.25 Kent.) compared with the control (6.37 Kent.). This study recommended using only one application of pheromone dispenser during the flowering growth stage of the cotton plants is sufficient to maintain the moth catches and infestation % in green bolls at the lowest level.

INTRODUCTION

Cotton, *Gossypium barbadence* L., known as "white gold", is still considered one of the most important economical crops in Egypt. Besides being exported, a substantial proportion of the crop is utilized by the local textile industry in the manufacture of garments and fabrics. As a cash crop, cotton has played an important role in improving the livelihoods of smallholder farmers (Zaki, 2012). Cotton plants are susceptible to infestation by several insect pest species during all its different growth stages but the most serious ones are mainly related to the damage of green bolls that caused by the cotton bollworms. Among them, is the pink bollworm (PBW), *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) (Amin and Gergis, 2006). The pest attacks fruiting portions, flowers and green bolls reducing both quantity and quality of harvested lint and seeds by (about 30-40% losses) in late season (Hamed & Nadeem, 2010 and Zaki, 2012).

The major control method of the cotton pests, especially the bollworms, is still depended upon chemical pesticides (Mohamed *et al.,* 2010).

Careless or excessive use of pesticides often results in poor control due to their drastic effects on natural enemies, besides high expenses and hazards to health and environment (Atwal, 1994).

Contrary to that, developing alternative non-chemical tools, effective and environmental friendly to suppress pests' infestation to cotton plants are essentially needed. Therefore, use of the sex pheromone-mediated mating disruption technique has proven successful cases for controlling of several moth pests of field crops, orchards and vineyards (Pree *et al*., 1994 and Carde & Minks, 1995). Use such technique against PBW in the cotton fields is a very compatible component that has been applied in Egypt for years. Permeating the insect's environment with synthetic sex pheromone could prevent the females to mate and thus, not to lay viable eggs. The technique was fully registered by the Environment Protection Agency (EPA) in different countries for the control of PBW in cotton. This technique has been successfully demonstrated in USA, Egypt and Pakistan (Ahmad and Sarwar, 2013). Major advantages of the pheromones are their safety to the beneficial insects and they can completely replace conventional insecticides for PBW control (El-Heneidy *et al*., 1987; Moawad *et al*., 1991 and Nazir *et al.,* 1996).

The aim of this study was to evaluate a non-chemical control program depends upon using the mating disruption technique for suppressing the infestation of PBW in cotton fields at Assuit Governorate (Upper Egypt).

MATERIALS AND METHODS

This study was conducted at an area of one feddan (4200 m^2), located at Assuit Governorate, Upper Egypt, cultivated with the Egyptian cotton (variety Giza 90), sown on 25th and 16th of March in the two growing seasons 2013 and 2014, respectively. In the experimental field, mating disruption technique was implemented, whereas another field, about 1Km away from the experiment, was used as control (un-treated). Pheromone treated fields and the control were surrounded by sorghum and corn in the first season 2013 and by cotton, sorghum, okra, and corn in the second one 2014. In both fields, regular agricultural practices were applied and no insecticides were used in both seasons.

Population monitoring

Population of PBW was monitored in both treated and control fields, using sex pheromone trap (Delta sticky trap). One trap/ experimental area was installed on 27th and 19th of June in 2013 and 2014, respectively. The trap was hanged at the top level of the plant canopy and the bait was renewed at 15 day interval throughout the sampling period. Moth catches were recorded twice a week up to the end of season (harvest).

Mating disruption (PB-ROPE)

Mating disruption was implemented on 30th and 22nd of June in the two growing seasons, respectively, at the rate of 300 PB-rope dispensers in each year. The dispensers were made from Shin-Etsu Chemical Co. Ltd. (Tokyo, Japan) (Fig. 1). The length of each dispenser was 200 mm and 2.5 mm in diameter and contained 78 mg (AI) of gossyplure ((ZZ) / (ZE) - 7, 11-hexadecadienyl acetate), the sex pheromone for PBW. Dispensers were twisted by hand around the main stem of the plant and above the first one or the two pairs of real leaves (Fig. 2). Potential of the technique in reducing moth population was estimated using the formula of (Critchley *et al*., 1991):

$$\text{Disruption \%} = \frac{\text{Control plot catch - treated plot catch}}{\text{Control plot catch}} \times 100$$

Boll infestation

Weekly samples of 75 green cotton bolls were collected randomly from both treated and control fields. Sampling started July 1st and June 30th in the two seasons, respectively, and continued until the majority of the bolls were opened (3rd week of September, 2013 and 4th week of August, 2014). Samples were kept in cloth bags and transferred to the laboratory for inspection and estimation of the percentages of infestation with the PBW by dissecting the green bolls according to (Abd El-Salam *et al.*, 1991). Infestation records, based on existence of injury symptoms regardless to the presence of larvae, were estimated.

Fig. 1: Mating disruption pheromones.

Fig. 2: Pheromone dispensers twisted by hand around the main stem of the cotton plant.

Statistical analysis:

Data at the treated and un-treated areas were subjected to one-way analysis of variance (ANOVA), T-test using by the Advanced Statistical Analysis Package (ASAP)^{R} (Darwish *et al.*, 2012). Significant treatment means were separated using the least significant difference (LSD) at P≤0.05 level. Data

were arcsine √x transformed before analysis to meet normality.

RESULTS

Population monitoring (Trap catches)

In both seasons of study, the number of captured moths in the sex pheromone traps was much lower in the treated area as compared to that in the control field. Subsequently, the % of disruption in both seasons was near to 100%.

In season 2013:

Just before installation of PB-rope dispensers, the number of PBW moths caught in the trap in the treated field was much higher (16.00 males/trap) than that (1.00 male/trap) in the un-treated field (control) (Fig. 3A). In treating field, captures were suppressed totally (almost 100%) starting the 1st week of July (4-days post treatment) till the 2nd week of September (71-days post treatment). Then, catches gradually appeared from mid-September (81-days post treatment) till the end of season by early October, 7th (99-days post treatment), but the numbers continued to be lower than that in the un-treated fields.

In season 2014:

Generally, the numbers of moths caught in the trap during this season were lower than that of the first one. Data in Figure (3B) showed that the first number of PBW moths before applying the dispensers, was similar at both treated and un-treated areas (4.00 moths/trap). After 4-days of treatment (on June, 26th), no moths were caught and the number remained zero up to harvest time (by mid-September, 18th) (87-days post treatment) as compared to un-treated area. This proved that, mating disruption achieved (almost 100%) control till the end of the season. Then, the traps started to catch some moths after harvesting but with very low numbers (1.00 moth/trap) in comparison with the un-treated (27.00 moths/trap) which remained relatively higher. Statistical analysis proved highly significant differences between the mean captured numbers of PBW (16.75±3.46 moths/trap) and (6.70±1.00 moths/trap) in un-treated area compared with (0.50±0.20 moths/trap) and (0.12±0.06 moths/trap) in the treated one, with a P-value of 0.000** in the two cotton seasons 2013 and 2014, respectively.

Infestation level

This study was carried out to estimate the indirect effect of the mating disruption pheromone on suppressing PBW infestation level in green bolls as compared with those in un-treated area during the seasons of 2013 and 2014 in cotton fields at Assuit Governorate. Infestation rate of the cotton green bolls before applying the pheromone dispensers was (2.66%) in the first season, 2013 and was relatively higher (5.33%) in the second one, 2014 as compared to those in the un-treated area (4%) in both seasons (Fig. 4). In the treated area, % of infested bolls significantly decreased recording zero for 6 weeks representing (100%) reduction in the infestation. After this time, the infestation occurred, but at very low level in the treated area only. By early-September, the majority of bolls opened and infestation rate was (<10%) in 2013 as compared to those of un-treated field (49 %) by the end of this season (Fig. 4A). However, the infestation % in 2014 remained for three weeks in the un-treated area only (Fig. 4B). Finally, in both seasons the % of damage was peaked in August and September in the un-treated field. Statistical analysis of the obtained results of the two cotton seasons 2013 and 2014 showed highly significant differences between the mean infestation % with PBW (1.51±0.75& 0.89 ± 0.59) in the treated area and that in the un-treated (20.54±5.43 & 12.33 ±3.55), with paired t-test of (3.44** &3.29**) and P-value of (0.001**& 0.008**), respectively. At the end of each season, the cotton yield per feddan was estimated compared with control. Data revealed

that a lower yield occurred in un-treated plots where neither pheromones nor any insecticides were applied (Table 1).

Table 1: Cotton yield in cotton fields at Assuit Governorate treated with mating disruption with PB-rope dispensers and in control field in cotton growing seasons 2013 and 2014

Cotton production/feddan (kentar=157.5 kg)		
Treatments / Season	PB-rope pheromone	Control
2013	10	5.75
2014	10.5	7
Mean	10.25	6.37

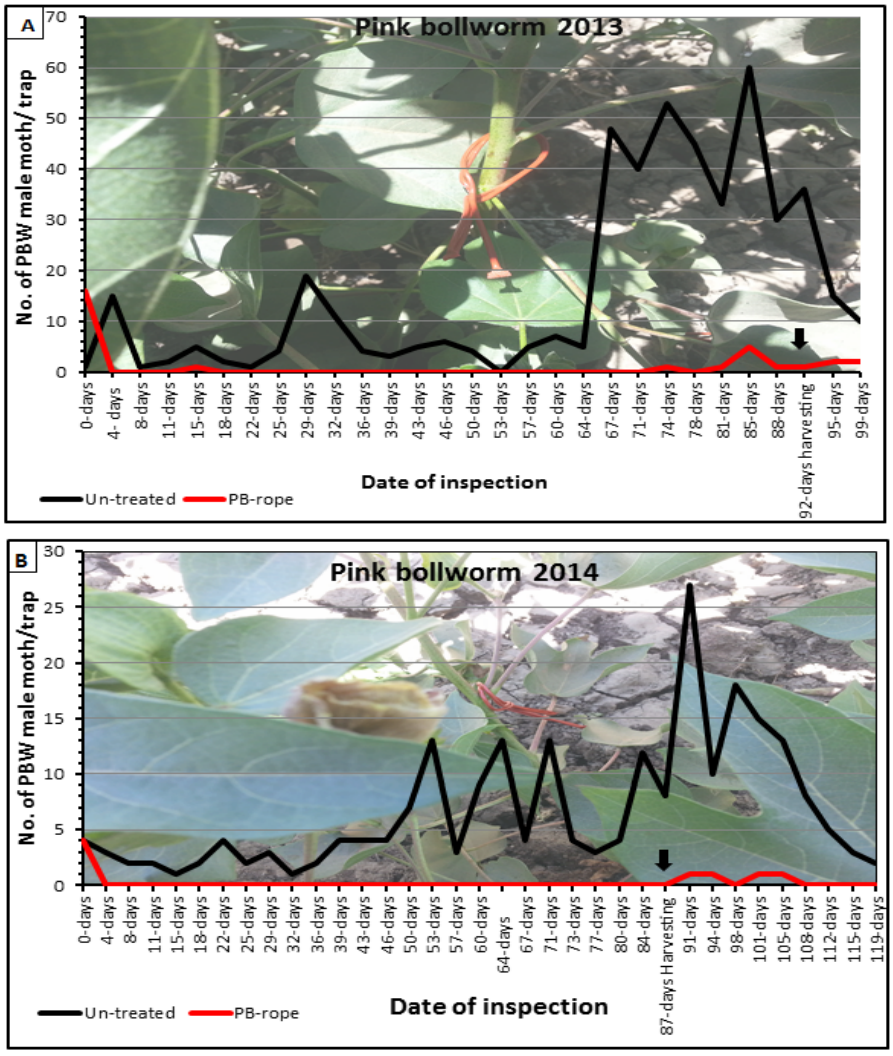

Fig. 3: Trap catches of PBW males in pheromone traps in cotton fields at Assuit Governorate where mating disruption (PB-rope dispensers) was applied and in the un-treated (control) fields, seasons 2013 and 2014.

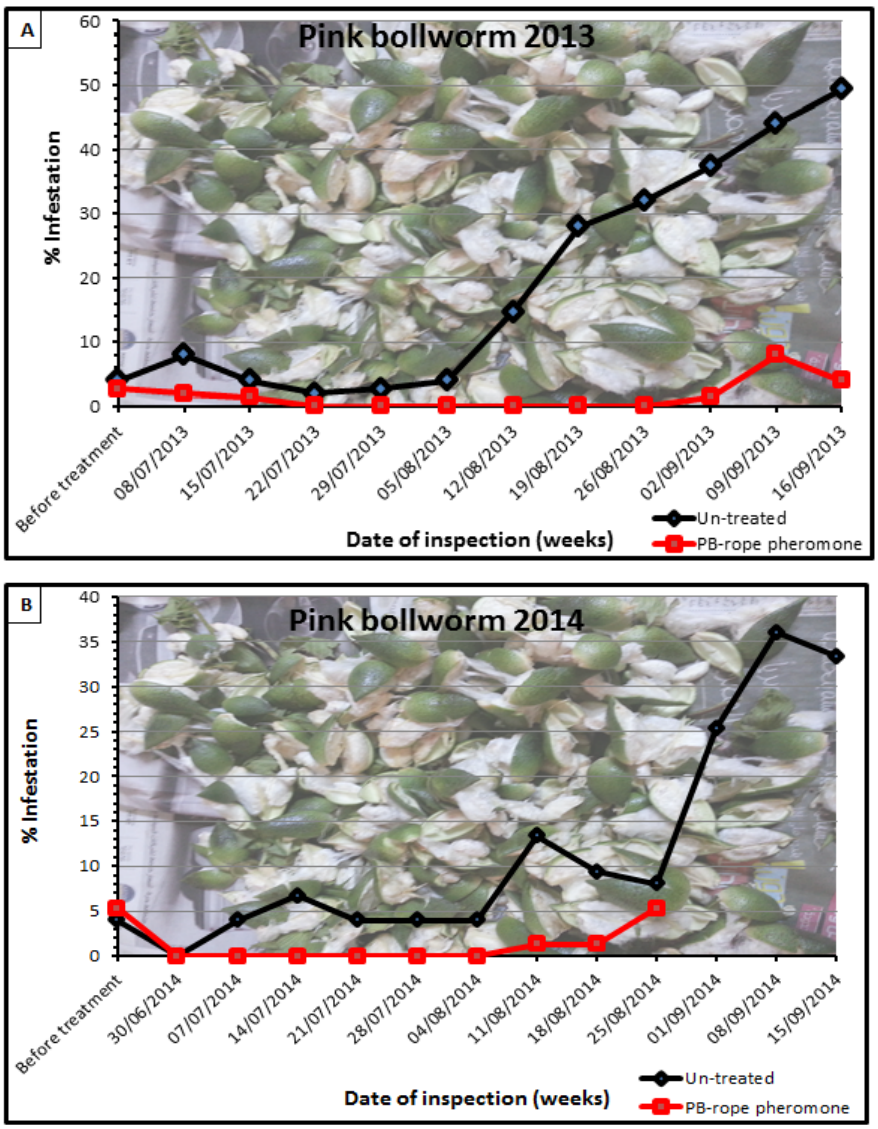

Fig. 4: Weekly percentages of infestation with PBW in cotton fields at Assuit Governorate where mating disruption with PB-rope dispensers was applied and in the control fields, seasons 2013 and 2014.

DISCUSSION

As a result of the feeding habits of PBW larvae inside the cotton bolls, direct contact with insecticides is very difficult and ineffective. Therefore, chemical control has not provided a long term solution for such cotton pest problems (Gressel *et al*., 2004). For these reasons, the effective and environmentally safe control approaches began to be explored, and many new measures and techniques were put into use in cotton pest control as a part of IPM (Ahmad *et al*., 2005).

Insects use specific chemicals called "pheromones" for communication. One of the most important pheromones is a "sex pheromones" which commonly used as a method of pest control with a technique termed "mating disruption" (Witzgall *et al*., 2010). Broadly, the mechanisms have been identified as a competition between synthetic point sources and authentic females (Miller *et al*., 2009), then the males are unable to locate their female mates and mating is therefore reduced or confused (Minks and Kirsch, 1998). Furthermore, the negative effects of delayed mating communication can significantly contribute for management of the pest population over time following pheromone application (Mori and

Evenden, 2013). Using of gossyplure for mating disruption has been proposed from several researchers, as an alternative tool for controlling of *P. gossypiella* (Staten *et al.,* 1987 and Cardé *et al.,* 1998). The application of this technique has given very promising results (Cardé *et al.*, 1998). In Pakistan, Critchley *et al.*, (1991) observed that early season control of this pest throughout 1985-1988 by mating disruption, permitted an average reduction of two applications of conventional insecticides. Moreover, in Greece, the mating disruption has been tested successfully, during the last few years as recorded by (Kyriakidou & Recca, 1991 and Yamvrias & Foundoulakis, 1995). In Egypt, this technique (PBW-rope) was used against this pest on large scale applications (thousands of acres) in cotton fields for many years as reported by (Albeltagy *et al.,* 1993). Moreover, El-Deeb *et al.*, (1993) reported that adequate control of PBW was achieved by one pheromone application and additional insecticide spray. In addition, El-Heneidy *et al.* (1987) and El-Adl *et al.* (1988) recorded greater numbers of beneficial insects in the pheromone-treated areas than that in the insecticide one.

Obtained results indicated that when PB-Rope dispensers were applied, the % of disruption in both seasons was near (100%) and significantly reduced the infestation rates in green bolls until the end of the season (harvesting). This positive impact of mating disruption technique applied in Upper Egypt are in similar line with those of (Critchley *et al.*, 1983; Qureshi *et al.,* 1993; Athanassiou *et al.*, 2002; Lykouressis *et al.,* 2004; Patil *et al.,* 2007 and Ünlu & Mezreli, 2011) who reported that moth catches in traps and damage caused by PBW in green bolls were much lower in the treated areas as compared with control, and it is an evidence of the high effectiveness rate of pheromone application, due to disruption of communication between males and females, consequently leading to mating disruption. Also, they added that, cotton yield of treated fields was increased than that of control.

In the present study, the efficiency of the pheromone dispensers extended for at least 2 months after the application till the end of cotton season. Similar findings was reported by (Haynes *et al*., 1984) who observed that after 60 days, the PB-rope still emits a synthetic pheromone with about 1500-fold higher rate than the mean emission by natural female 0.16 ng min^{-1}. In addition, (Flint *et al.*, 1985) recorded the initial release of pheromone from a dispensers was 685 ng min^{-1} at 25°C but after 60 days in the field it declined to 239 ng min^{-1}. Moreover, (Papa *et al.*, 2000) showed that only one application of 250 dispensers/ha in Brazil reaching (80%) of control for PBW and the release period from dispenser was 120 days. Similarly, in central Greece, Lykouressis *et al.* (2005) found that mating disruption was effective in preventing damage when applied in early season, but damage levels were not proportionally reduced in relation to the reduction of trap catches. Sufficient gossyplure for reducing moth catches in the traps was in pheromone dispensers even 90 days in the field.

In conclusion, this study recommended using only one application of pheromone dispenser during the 50% flowering growth stage of the cotton plants was sufficient to maintain the moth catches and infestation % in green bolls at the lowest level as compared to the un-treated area. This study is considered the first recent trial in cotton fields at Assuit Governorate, Upper Egypt, since 1992.

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ARABIC SUMMERY

المكافحة غير الكيميائية لدودة اللوز القرنفلية في حقول القطن في محافظة أسيوط ـ صعيد مصر باستخدام تقنية إعاقة التزاوج

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تناولت الدراسة تقييم تأثير استخدام تقنية إعاقة التزاوج بمعدل ٣٠٠ حبل فرموني (PB-Rope) للفدان في خفض تعداد ونسب الإصابة بدودة اللوز القرنفلية *Pectinophora gossypiella* (Saunders) في حقول القطن بمحافظة أسيوط (صعيد مصر) خلال موسمين متتاليين ٢٠١٣ و ٢٠١٤. اهتمت الدراسة بتسجيل دوري لتعداد فراشة الآفة في المصائد الفرمونية خلال مرحلة إزهار نباتات القطن (شهر يونيو)، وكذلك تقدير نسب الإصابة في اللوز الأخضر في كلا من الحقل المعامل بالفرمون مقارنة بغير المعامل (الكنترول). وقد أوضحت النتائج حدوث خفض تام (حوالي ١٠٠%) في تعداد الفراشات في المصائد في الحقل المعامل بتطبيق هذه التقنية، هذا بالإضافة إلي خفض ملحوظ في نسب الإصابة باللوز بلغ (٠.٨٩ & ١.٥١%) فى الحقل المعامل مقارنة بـ (٢٠.٥٤ & ١٢.٣٣%) فى الكنترول في كلا الموسمين، على التوالى. تم في نهاية كل موسم حساب متوسط معدل الإنتاج الكلي للفدان في كل من الحقل المعامل وغير المعامل، حيث سجلت النتائج زيادة معنوية في الإنتاجية، قدرت فى الحقل المعامل بالفرمون (١٠.٢٥ قنطار/فدان) مقابل (٦.٣٧ قنطار/فدان) فى الكنترول. ولذلك توصى الدراسة باستخدام معاملة واحدة فقط بهذه التقنية بدءا من مرحلة إزهار نباتات القطن قد يكون كافيا للمحافظة على تعداد فراشات الآفة والنسب المئوية للإصابة بها عند الحد الأدنى.