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Use of Pheromone Traps to Monitor Population Fluctuations of Cotton Leafworm Moth and Their Transmission in Winter and Summer Crop Fields

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ABSTRACT

These experiments were carried out in Lakana and Sharnub villages, El-Beheira Governorate, during the 2017, 2018, and 2019 seasons to study the crop type, regional and seasonal effects on male adults of *S. littoralis* caught by YWPT. The average numbers of moth, for sugarbeet, clovers and wheat were 7.57, 9.00, and 5.64 respectively, at Lakana village, and were 11.19, 10.70, and 8.77 respectively, at Sharnub village in winter crop fields during the 2017/2018 season. While during the 2018/2019 winter season, the average numbers of moth, were 13.95, 10.65, and 8.05 respectively, at Lakana village, and were 15.33, 10.38, and 13.18 respectively, at Sharnub village. Comparing moth numbers catches significant differences were noticed between the crops, where the average moth for sugarbeet higher than clovers and wheat.

The average numbers of moths, for soybean, maize and cotton were 61.00, 15.27, and 70.50 respectively, at Lakana village, where it was 74.23, 23.80, and 87.80 respectively, at Sharnub village in the 2018 summer season. During the 2019 summer season, the average numbers of moths, were 63.05, 24.40, and 75.10 respectively, at Lakana village, and were 71.29, 28.13, and 103.40 respectively, at Sharnub village. However, moth numbers catch significant differences were noticed between the crops, where the average moth for cotton and soybean higher than maize. Also, all treatments were showed significant differences between both locations and between the winter and summer crops.

INTRODUCTION

The noctuid moth of the cotton leafworm, *Spodoptera littoralis* (Boisduval), (Lepidoptera: Noctuidae) is a native pest to Africa, it is found widely in the Mediterranean region (El-Khawas and Abd El-Gawad, 2002; Tanani *et al.*, 2015). It is well known as one of the most destructive agricultural lepidopterous pests within its subtropical and tropical range. The larvae interfere with plant development by destroying growth points and flowers as well as hollowing out the seed bolls, which often causes them to wilt and drop (Croft 1990). In Egypt, larvae infesting cotton, maize, soybean, sugar beet, and clover plants as

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well as more than 29 hosts from other crops and vegetables (Pluschkell *et al*., 1998; Abdel-Aal, 2012 and Korrat *et al*., 2012).

The intensive uses of many synthetic insecticides lead to the destruction of the natural enemies (like parasites, predators), allowing an exponential increase of pest populations (Naqqash *et al*., 2016) and serious toxicological hazards to humans (Costa *et al.*, 2008; Mosallanejad and Smagghe, 2009). Over the past five decades, the intensive and continuous use of broad-spectrum insecticides against *S. littoralis* had led to the development of its resistance against many registered insecticides and some insect growth regulators (Aydin and Gurkan, 2006; Mosallanejad and Smagghe, 2009; Rizk et al., 2010). To avoid the previously mentioned hazards of chemically synthetic insecticides, it is important to search for new effective and safer ways with negligible effects on the ecosystem (Dubey *et al*., 2010; Chandler *et al*., 2011; Korrat *et al*., 2012).

Lepidoptera is the second-largest insect group, including about 150,000 species in the world. It is common that two and more species share the same geographical location and occurrence time (Yan *et al*., 2019). Therein, the species-specific sex pheromones in addition to morphological and physiological characteristics play an important role in reproductive isolation (Yan *et al*., 2019; Allison and Cardé, 2016). Also, chemoreception plays an important role in insect behaviors, such as searching for food and mates, suitable hosts, and oviposition sites (Silvegren *et al*. 2005; Rong *et al*., 2015). Finding a female to mate with is a key event in the life of an adult male moth. For this purpose, many moth species rely on long-range species-specific sex pheromones (Raina and Menn, 1987). Since calling behavior in most moth species coincides with peaks in mating frequency (Dreisig, 1986), the female sex pheromone is not only a long-range indication of a female's location but also a sign that she is physiologically ready to mate (Liang and Schal, 1993 and Silvegren *et al*., 2005).

Sex pheromones are important for agricultural pest control (Yan *et al.* 2019). The use of pheromones to control phases of the lives of pest species is one method of pest management (Abdel-Moety *et al*., 2012). Pheromones can be used to monitor insect populations or to control directly certain pest species by the lure and trap unwanted or harmful insects (Campion, 1983). Sex pheromones have been successfully used for monitoring, mass trapping and mating disruption of a diversity of lepidopteran insect pests including cotton leafworm (Wyatt, 1998). Pheromone trap data gives an early warning of the infestation and also exhibits the density of the insect population.

This work aims to evaluate the use of pheromone traps to monitor population fluctuations of cotton leafworm moth and their transmission in winter and summer crop fields and determine to lure of cotton leafworm moth to which crop fields during 2017, 1018, and 2019 seasons at Lakana and Sharnub villages, El-Beheira Governorate. This information can be used to develop a strategy to suppress the cotton leafworm moth population as a tool for the integrated pest control program.

MATERIALS AND METHODS

Trap and Pheromone:

- **Trap:** Yellow plastic water traps (YPWT) with diameters (34 Cm * 24 Cm* 11 Cm) were used as continuous monitoring of population fluctuations of cotton leafworm Moth.
- Pheromone: The sex pheromone (9:1 mixture) of (Z9, E11) and (Z9, E12)-tetradecadienyl acetate was used as a specific sex attractant for cotton leafworm Moth and have been obtained from Plant Protection Research Institute, Agriculture Research Center, Cairo, Egypt.

Experimental Location:

All the field trappings were carried out in two villages, Lakana and Sharnub El-Beheira Governorate, during the 2017, 2018, and 2019 seasons. The winter crops were Sugarbeet, Clovers, and Wheat and the summer crops were Soybean, Maize, and Cotton. All cultural practices were carried out as recommended for optimal production for all crops.

Experimental Design:

Three traps (YPWT) were used for each crop. Every trap baited with one capsule containing 1mg of a mixture of *Spodoptera* pheromones, changed and replaced by a new one every 14 days. Traps were positioned at 120 cm above ground level. The traps are filled with soapy water and renewed every week and increased some water to overcome the evaporation of water). The numbers of captured adult males were counted during the 2017, 2018, and 2019 seasons.

Statistical Analysis of Data:

The data was analyzed using CoStat Statistical software1998, according to the statistical procedure of analysis of variance (ANOVA), and in case of significant differences, (L.S.D) at a 5% level of probability.

RESULTS

The monitoring count of *Spodoptera* adults in YPWT within the winter season in crops Sugar Beet, Clovers, and Wheat in the two villages, Lakana and Sharnub during two seasons 2017/ 2018, and 2018/2019 are shown in tables 1and 2. During 21 weeks monitoring count of *Spodoptera* adults on sugar beet crop, the mean counts of *Spodoptera* adults of Sharnub village were higher than Lakana village in both seasons. As well The average capture numbers of moths during season 2018/2019 were higher than the season 2017/2018 in both villages with a mean count of 15.33, 11.19 and 13.95, 7.57 in the two villages Sharnub and Lakana during two seasons 2018/2019, and 2017/2018 respectively.

Caught scan of *Spodoptera* moth on wheat crop meanwhile 22 weeks had the same pattern as in sugar beet crop; the mean caught counts of *Spodoptera* adults of Sharnub village were higher than Lakana village in both seasons. Also, the average capture numbers of moths during season 2018/2019 were higher than the season 2017/2018 in both villages with a mean count of 13.18, 10.65 and 8.77, 5.64 in the two villages Sharnub and Lakana during two seasons 2018/2019, and 2017/2018 respectively.

The observation of the caught number of *Spodoptera* adults within 32 weeks on clovers showed that in season 2017/2018 the mean caught number of *Spodoptera* adults of Sharnub village were higher than Lakana village with a mean count of 11.70 and 9.00 respectively. While in season 2018/2019 there was no significant difference between the two villages Sharnub and Lakana with a mean count of 10.65 and 10.38 respectively. The two seasons 2017/2018 and 2018/2019 were no significantly different regarding the average caught the number of *Spodoptera* moth.

Over the investigated winter crops sugar beet, clovers and wheat, Sugar beet showed the highest mean number captured of *Spodoptera* moths within two villages during the two seasons, the average numbers of moth, for sugarbeet, clovers and wheat were 7.57, 9.00, and 5.64 respectively, at Lakana village, where it was 11.19, 10.70, and 8.77 respectively, at Sharnub village during season 2017/2018. For the 2018/2019 season, the average numbers of moths were 13.95, 10.65, and 8.05 respectively, at Lakana village, and were 15.33, 10.38, and 13.18 respectively, at Sharnub village.

Data shown in tables (3and4) summarized the population fluctuation of male adults of *Spodoptera* littoralis caught by YPWT in summer crop fields' soybean, maize, and cotton during the 2018 and 2019 seasons .The population fluctuation of *Spodoptera* moth in soybean during 17 weeks’ season 2018 in the two villages Lakana and Sharnub showed no significant differences with mean count 61 and 74.23 respectively. While during season 2019 population fluctuation of *Spodoptera* moth count was higher in Sharnub village than Lakana village with mean count 71.29 and 63.05 respectively.

Table 1: Weekly number of cotton leafworm moth in winter crop fields during season 2017/2018

Date		Mean numbers of male moth /trap					
		Lakana			Sharnub		
		Sugarbeet	Clovers	Wheat	Sugarbeet	Clovers	Wheat
October	7	13	-	-	22	10	-
	14	12	-	-	24	22	-
	21	23	14	-	31	14	-
	28	19	11	-	18	14	-
November	4	20	7	-	27	11	-
	11	14	5	-	26	4	-
	18	11	3	-	14	3	-
	25	9	2	-	10	4	-
December	2	4	1	-	3	8	-
	9	5	0	1	7	2	2
	16	7	0	0	2	0	4
	23	3	1	0	5	0	1
	30	6	2	0	9	1	2
January	6	5	1	0	4	4	3
	13	1	1	0	4	2	4
	20	2	3	0	7	0	1
	27	0	1	0	4	0	0
February	3	0	0	0	5	1	0
	10	0	0	0	7	1	1
	17	4	2	4	4	4	4
	24	1	3	6	2	7	1
March	3	-	4	10	-	1	7
	10	-	2	14	-	9	17
	17	-	5	13	-	6	22
	24	-	7	12	-	8	11
	31	-	11	15	-	4	8
April	7	-	13	9	-	11	11
	14	-	22	11	-	19	7
	21	-	24	8	-	31	21
	28	-	21	2	-	36	33
May	5	-	26	19	-	42	33
	12	-	35	-	-	27	-
	19	-	28	-	-	51	-
	26	-	33	-	-	41	-
General mean		7.57 bc	9.00 ab	5.64 c	11.19 a	11.70 a	8.77abc

Means within the same column followed by the same letters are not significantly different according to the $LSD_{0.05}$

During season 2018 the mean caught *Spodoptera* moth numbers within 15 weeks in maize crop in the two villages Lakana and Sharnub showed no significant differences with mean count 15.27 and 23.8 respectively. But during season 2019 showed significant differences between the two villages Lakana and Sharnub with a mean count of 24.4 and 28.13 respectively.

In the cotton field, the monitoring count of *Spodoptera* adults during season 2018 in both villages Lakana and Sharnub showed no significant differences with mean count 70.5 and 71.8 respectively. In season 2019 the monitoring count of *Spodoptera* adults showed significant differences in the two villages, the mean capture moth count of Sharnub village significantly higher than Lakana village's mean capture moth count, 103.4 and 75.1respectively.

Table 2: Weekly number of cotton leafworm moth in winter crop fields during season 2018/2019

Date		Mean numbers of male moth /trap					
		Lakana			Sharnub		
		Sugarbeet	Clovers	Wheat	Sugarbeet	Clovers	Wheat
October	6	16	-	-	29	9	-
	13	19	-	-	22	12	-
	20	20	22	-	19	19	-
	27	22	20	-	27	24	-
November	3	29	17	-	29	18	-
	10	27	17	-	21	14	-
	17	31	18	-	11	9	-
	24	21	8	-	19	7	-
December	1	22	10	-	7	2	-
	8	17	7	1	11	0	0
	15	18	1	2	7	0	1
	22	23	3	0	8	0	1
	29	11	2	0	11	0	1
January	5	9	2	1	7	0	2
	12	2	2	1	4	1	4
	19	2	1	2	12	0	7
	26	0	0	3	14	0	2
February	2	1	0	5	17	1	7
	9	2	0	4	11	1	6
	16	0	2	7	14	4	8
	23	1	1	6	22	1	7
March	2	-	1	14	-	1	11
	9	-	2	17	-	5	14
	16	-	1	17	-	7	28
	23	-	4	12	-	11	30
	30	-	14	11	-	9	14
April	6	-	17	17	-	10	19
	13	-	20	18	-	14	21
	20	-	18	17	-	26	28
	27	-	19	12	-	31	38
May	4	-	20	10	-	33	41
	11	-	24	-	-	21	-
	18	-	30	-	-	29	-
	25	-	38	-	-	34	-
General mean		13.95 ab	10.65 bc	8.05 c	15.33 a	10.38 bc	13.18 ab

Means within the same column followed by the same letters are not significantly different according to the $LSD_{0.05}$.

During the summer seasons 2018 and 2019 on the fields of soybean, maize, and cotton crops, the moth numbers catch significant differences were noticed between the crops, where the average moth for cotton and soybean higher than maize. Also, all treatments were showed significant differences between both locations and between the winter and summer crops, with average numbers of moth, for soybean, maize and cotton were 61.00, 15.27, and 70.50 respectively, at Lakana village, where it was 74.23, 23.80, and 87.80 respectively, at Sharnub village at 2018 season. For the 2019 season, the average numbers of moths, were 63.05, 24.40, and 75.10 respectively, at Lakana village, and were 71.29, 28.13, and 103.40 respectively, at Sharnub village.

Table 3: Weekly number of cotton leafworm moth in summer crop fields during season 2018

Date		Mean numbers of male moth /trap					
		Lakana			Sharnub		
		Soybean	Maize	Cotton	Soybean	Maize	Cotton
May	5	-	-	-	-	-	-
	12	-	11	-	-	41	-
	19	-	14	54	-	56	44
	26	-	32	51	-	35	47
June	2	28	47	48	41	29	68
	9	47	31	51	54	47	74
	16	110	24	81	157	28	42
	23	94	33	99	112	21	74
	30	123	11	144	98	17	89
July	7	198	4	212	214	11	245
	14	98	8	297	185	24	411
	21	44	9	61	74	17	39
	28	41	3	49	47	11	68
August	4	37	1	44	37	8	49
	11	29	1	43	64	5	33
	18	52	0	38	24	7	19
	25	28	-	27	41	-	18
September	1	32	-	17	51	-	29
	8	24	-	19	27	-	35
	15	41	-	12	17	-	24
	22	11	-	22	19	-	11
	29	-	-	41	-	-	17
General Mean		61.00 a	15.27 b	70.50 a	74.23 a	23.80 b	71.80 a

Means within the same column followed by the same letters are not significantly different according to the $LSD_{0.05}$.

Table 4: Weekly number of cotton leaf worm moth in summer crop fields during season 2019

Date		Mean numbers of male moth /trap					
		Lakana			Sharnub		
		Soybean	Maize	Cotton	Soybean	Maize	Cotton
May	4	-	-	-	-	-	-
	11	-	21	-	-	34	-
	18	-	27	10	-	74	9
	25	-	51	21	-	41	11
June	1	22	61	31	17	37	15
	8	40	75	55	21	51	32
	15	85	40	47	54	34	41
	22	141	24	244	87	31	68
	29	147	19	45	141	24	351
July	6	181	14	214	188	34	89
	13	127	3	311	191	33	247
	20	45	11	95	57	14	411
	27	37	8	51	71	9	310
August	3	51	7	34	55	4	87
	10	21	2	31	51	1	64
	17	41	3	71	34	1	88
	24	34	-	64	55	-	45
	31	39	-	57	74	-	74
September	7	20	-	41	47	-	28
	14	20	-	36	44	-	30
	21	21	-	29	25	-	44
	28	-	-	15	-	-	24
General mean		63.05 bc	24.40 d	75.10 ab	71.29 ab	28.13cd	103.40 a

Means within the same column followed by the same letters are not significantly different according to the $LSD_{0.05}$.

DISCUSSION

Insects communicate by means of scents–pheromones, chemicals used for 'signaling'. With these, they both locate and identify their mates. Female insect typically puffs out a thousand millionth of a gram of her signature several times a minute. Males of her species follow this scent to mate with the female. It follows that if you can identify and then duplicate that scent, you have the means of controlling the males of that species. This is the mysterious incidence of pheromone technology. One of the most important applications of pheromones, which use it in the integrated pest management of insects is a population monitoring of insects to determine if they are present or absent in an area or to determine if enough insects are present to warrant a costly treatment. This monitoring function is the keystone of integrated pest management. Also, continuous monitoring of population fluctuations is important to improve the control of economic pests (Shuker *et al*., 2014 and Abd El-Ghany 2020).

The obtained data showed the efficiency of YPWT to describe the development of average numbers of male adults of *S. littoralis* caught in winter and summer crop fields during the 2017, 2018, and 2019 seasons. The use of pheromones in pest management programmers for detection, monitoring and timing of pesticide spray of *Spodoptera litura* in India (Singh and Sachan 1993), in Egypt (Elghar *et al*., 2005) and in Bangladesh (Islam, 2012). In the same manner, Duraimrugan and Alivelu (2018) used the pheromone trap as a tool for determining the action threshold of *S. litura* based on the number of moths caught. They concluded that the pheromone trap based on the action threshold identified can be used to forecast the seasonal status of *S. litura*.

Weather factors are influencing factors affecting insect life and activity. These factors may be utilized to gain some insight into the size and behavior of the field population and consequently into the history and ultimately prediction of the future generation (Dahi, 2007, and El-Mezayyen and Ragab, 2014). Our results indicated that the moth numbers caught within the two summer seasons 2018 and 2019 on all crop fields significantly higher than the moth numbers caught within the two winter seasons 2017/2018 and 2018/2019 on both village sites. These are in agreement with those obtained by Nandihalli *et al*. (1989), Taman (1990), Singh and Sachan (1991), Al-Beltagy *et al*., (1999); Chaudhari *et al*. (1999), Gedia *et al*. (2008), and Yones *et al*.;(2012) that showed the development of insects is temperature-dependent, and the organism requires a heat accumulation to complete development.

Plants also represent a significant part of the natural environment for moths and emit many diverse volatile compounds, which depend on the plant species and its physiological state (Niinemets *et al*., 2004) or the circadian rhythm (Fang *et al*., 2018). The host plant provides food sources, habitats, and oviposition sites for phytophagous insects (Bruce *et al*., 2005). Habitats create an unpredictable odorant background that can interact in various ways by perceiving specific signals and then synergizing or suppressing responses to the female-produced pheromones (Fang *et al*., 2018). On the other hand, the effect of plant volatiles on the male moth behavioral response to sex pheromone has long been investigated (Landolt and Phillips 1997; Reddy and Guerrero 2004). Perception of sex and plant volatiles typically employs discrete peripheral input channels, and two different types of insect olfactory receptors, pheromone and general odorant receptors, respectively (Krieger *et al*. 2004; Sakurai *et al*. 2004; Zhang and Löfstedt, 2015). Our result showed the preference attractant behavior of *Spodoptera* moth males to crop more than others under the same weather factors and sex pheromone availability, in winter crops Sugar beet has more attractive than clovers, while wheat was the lowest attractive within the three crops under study. Also, the preference attractant behavior of *Spodoptera* moth males showed in summer crops, cotton was the more attractive crop *Spodoptera* moth males followed by soybean and the less attractive crop within summer crops was maize. The behavioral role of plant volatiles in male moth sexual behavior has not been entirely resolved. It has been proposed that host plant volatiles mediate male attraction to mating sites either by themselves, before the onset of pheromone released by females, or by synergizing the response to sex pheromone (Landolt and Phillips 1997; Reddy and Guerrero 2004; Beyaert and Hilker 2014). In some species, host plant volatiles increase male attraction towards sex pheromone (Dickens *et al*. 1993; Light *et al*. 1993; Yang *et al*. 2004; Schmidt-Büsser *et al*. 2009; Varela *et al*. 2011; von Arx *et al*. 2012), whereas they produce an antagonistic effect in other species (Pregitzer *et al*. 2012; Jung *et al*. 2013; Party *et al*. 2013; Rouyar *et al*. 2015). This kind of synergism by plant volatiles has been also reported in the male tobacco budworm *Heliothis* virescens (Dickens *et al*., 1993). In addition, host plant volatiles significantly synergized responses in male *Helicoverpa zea* insects (Ochieng *et al*., 2002 and Fang *et al*., 2018). It could be stated that our findings agree to a great extent with those obtained by Rizk *et al*., (1990); Downham *et al*., (1995) and Mesbah *et al*. (2004), where the reproductive behavior of cotton leafworm depends on the presence of host or non-host plants (Sadek and Anderson, 2007 and Martel *et al*.; 2009).

Monitoring results showed that the average caught values of cotton leafworm moth in Sharnub village always higher than the average caught values in Lakana village, we could explain that through the agricultural pattern in both villages. in Sharnub village, farmers heavily and continuously cultivate vegetables and crops more than in Lakana village, which could be the reason for the difference.

Our study concluded that yellow plastic water traps (YPWT) with The sex pheromone (9:1 mixture) of (Z9, E11) and (Z9, E12)-tetradecadienyl acetate is sufficient tool to monitor population fluctuations of cotton leafworm moth and their transmission in winter and summer crop fields and gave clear indicators of higher population count peaks of the moth to can intervene with the convenient control method, also it can be used as itself as proper control tool through mass trapping technique, moreover, the collected information can be used to develop a strategy to suppress the cotton leafworm moth population as a tool for the integrated pest control program.

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ARABIC SUMMARY

إستخدام المصائد الفرمونية لرصد التقلبات السكانية لعثة دودة ورق القطن وإنتقالها في حقول المحاصيل الشتوية والصيفية

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أجريت هذه التجارب في قريتي لقانه وشرنوب بمحافظة البحيرة خلال مواسم 2017 و 2018 و 2019 لدراسة التاثيرات الإقليمية والموسمية و التنوع المحصولى على معدل إصطياد ذكور فراشة دودة ورق القطن بواسطة المصائد افرمونية المائية. أوضحت النتائج، أن متوسط أعداد الفراشات على بنجر السكر والبرسيم والقمح 7.57 ، 9.00 و 5.64 على التوالي في قرية لقانه ، وبلغت المتوسطات 11.19 ، 10.70 و 8.77 على التوالي في قرية شرنوب في حقول المحاصيل الشتوية خلال موسم 2018/2017. بينما بلغ متوسط أعداد الفراشات خلال موسم شتاء 2019/2018 ، هي 13.95، 10.65 و 8.05 على التوالي في قرية لاكانا و 15.33 ، 10.38 و 13.18 على التوالي ب شرنوب. لوحظت فروق معنوية بين تعداد الفرشات على المحاصيل، حيث كان متوسط التعداد على بنجر السكر أعلى من البرسيم والقمح.

كما بلغ متوسط أعداد الفراشات لفول الصويا والذرة والقطن 61.00، 15.27 و 70.50 على التوالي بلقانه، كما كانت 74.23 ، 23.80 و 87.80 على التوالي بشرنوب في موسم صيف 2018. أما خلال موسم صيف 2019 ، بلغ متوسط أعداد الفراشات 63.05، 24.40 و 75.10 على التوالي بلقانه و بلف المتوسط 71.29 ، 28.13 و 103.40 على التوالي في قرية شرنوب. كما لوحظت فروق معنوية في أعداد الفراشات بين المحاصيل، حيث كان متوسط الفرشات على محاصيل القطن وفول الصويا أعلى من الذرة. كما أظهرت جميع المعاملات اختلافات معنوية بين كلا الموقعين وبين المحاصيل الشتوية والصيفية.