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DIFFERENT MODELS OF PINK BOLLWORM *PECTINOPHORA GOSSYPIELLA* SAUNDERS TRAP CATCHES AND BOLL INFESTATION RELATIONSHIPS UNDER DIFFERENT CONDITIONS

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Abstract

Pink bollworm *Pectinophora gossypiella* Saunders (PBW) is the most destructive cotton pest in all cotton growing areas of the world. Forecasting PBW moths population density and dynamics by using the pheromone delta sticky traps is a vital tool for directing pest control operations. The correlation between PBW trap catches and PBW infestation in green bolls is of great importance in this aspect.

Under nine different control tactics for PBW control pheromone and / or insecticides treatments, the correlation coefficient and regression equation models have been estimated. It was found that every control tactic had its own regression equation model. It was also found that the correlation coefficient and the regression equation model differs from early, mid to late season. The overall correlation coefficient and the regression equation model was estimated.

The estimated boll infestation percentages (dependent variable) under different PBW control tactics, and dates of inspections, by using the given estimated parameters, were almost very close to the actual ones.

INTRODUCTION

The pink bollworm (PBW) is a pest of great importance worldwide. Because it has been studied so intensively, and because control tactics for it have become too numerous to be tested in the field, PBW is an ideally suited subject for simulation analysis (Sterling et al., 1989)

Gossyplure, the sex pheromone of the PBW, has been identified as 1:1 ratio of Z,Z - and Z.E. isomers of 7,11 hexadecadienyl acetate (Hummel *et al.* 1973). Gossyplure has been used extensively for survey and detection (Foster *et al.* , 1977) and as a monitoring technique to determine the need for control action and in evaluating the effectiveness of treatment in the suppression of PBW population (Toscano *et al.* 1974).

Many authors had studied the relationship between PBW trap catches and boll infestation under different conditions (Hanneberry & Clayton 1982; Beasly *et al.* , 1984; Henneberry & Beasly 1985; Henneberry 1986; Adams *et al.* 1986; Beasly *et al.* , 1986; Hamid *et al.* , 1994). Many other authors reported different models for PBW (Gutierrez *et al.* , 1977, Sevacherian *et al.*, 1977; Bartlett and Butler 1979; Butler and Watson 1980; Huber 1982).

The present work is an attempt to devise models of correlation between trap catches and boll infestation with the pink bollworm at nine different inspection times and under different control tactics.

MATERIALS AND METHODS

In 1992 cotton season, 450 cotton feddans in Beheira governorate (Kafer El-Dawar district, Kom Esho village) were put under nine different chemical contro! tactics comprising pheromones and insecticides in a sequential order as demonstrated in Table (a). Sprays were carried out at 14 day intervals. The following procedures were carried out:

Treatments

Nine different control tactics were applid as shown in Table (a).

Trap catches

Delta sticky traps provided with PBW sex pheromone vials (gossyplure 1 mg/ vial, supplied by Pheromone Corporation, Inc., Phoenix, AZ, USA) were installed in the different areas treated by the rate of 1 trap / 10f. The traps were installed from 18 June and up to 6 September 1992. The pheromone sources (vials) were replaced every 14 days. Trap catches (Pbw male moths / trap / week) were counted and recorded on weekly basis.

Boll Infestation %

Under the different treatments, 3 boll samples (each of 100 bolls) were weekly collected, transferred to the laboratory, dissected, and boll infestation percentages were calculated and recorded. The boll samples were collected 8 times from July 16 and up to September 6, 1992.

PBW trap catch and Boll Infestation % Relationships

Under the different treatments, the PBW trap catch means (male moth / trap / week) were correlated to the means of boll infestaion % in each treatment. These correlations were carried out from July 16 to September 6 only.

Statistical Analysis Procedures

The means, standard Deviations (STDEV), Correlation Coefficient (r), Probability Value (p), Coefficient of determination (r-square), Slope (b), intercept (a), were calculated by using SAS software (Ver. 6.20, 1993) for correlation and regression procedures.

Other Values and Modeling Procedures

The relative treatment efficacy (b treatmen / b insecticide) or overall (100), recovery of boll infestation % mean (applying the mean of trap catch to the model to generate the expected mean of boll infestation %), model efficiency (calculated mean of boll infestation % / true infestation mean (100), and the expected Y (boll infestation %) when X (trap catch mean) = 8 male moth /trap / week. The 8 male moth were chosen as a trigger for control action against PBW. All these values and the regression model equations were calculated and built up by using EXCEL software (ver .4.0).

Graphic Procedures

Figures 1 and 2 and their components were generated by Harvard Graphics software (Ver.3.0) using the trend and draw procedures.

RESULTS

1- Different Treatment Models

Results of this study and the statistical analysis produced by SAS are shown in Table 1 and illustrated in Fig. 1 and its components. The following statistical analysis values are shown:

1.1 Regression value (b)

The highest regression value, between pbw trap catch (independent variable X) and boll infestation % (dependent variable Y), is that of the insecticide treatment (0.59), although it had one of the intermediate trap catches in early season (23.5 male / trap / week). On the other hand, the combined 3 treatments showed the lowest regression value (0.06), although it had one of the high trap catches by early season (32.5 male / trap/week). This means that the increase of 1 pbw male moth/ trap / week, in the insecticide treatment, had caused the highest increase in boll infestation% (0.59 %) , while the increase of 1 pbw male moth/trap/week, in the combined 3 treatments, caused the lowest increase in boll infestation % (0.06 %). The other seven treatments had regression values that lied between the two mentioned treatments.

1.2. Relative treatment efficacy %.

Based on the highest regression value showed by insecticide treatment, the other 8 treatment regression values could be arranged relatively to it. Thus, the highest negative treatment efficacy was due to the combined 3 treatment, whereas the increase of 1 pbw male moth/ trap / week had a decrease in boll infestation % compared to the insecticide treatment (89.83%), while the lowest negative treatment efficacy was due to the sequential 2 treatment (- 18.64%). This might be due to the high trap catch mean two weeks before modeling (34.0).

1.3. The correlation Analysis

1.3.1 The correlation Coefficient and probability Value

Comparing the correlation coefficient (r) and the probability value (P) had revealed only one highly significant correlation in the case of the combined 2 treatment ($r = 0.78$, $P = 0.005$), while there were two significant correlations in case of the insecticides treatment ($r = 0.80$, $p = 0.017$) and the sequential 2 treatment (r

= 0.78 , p = 0.019). In the other six treatments the correlations were not significant.

1.3.2. The Coefficient of Determination

The Coefficient of determination (r-Square) determines how much the X variable (PBW trap catch) affected the Y variable (boll infestation %). The results shown in Table 1 pointed out that in case of the combined 2 treatment, 75.7% of boll infestation percentages was due to pbw trap catch. In the insecticides treatment, the pbw trap catch affected boll infestation percentages by 64.0% , while in the sequential 2 treatment the effect was 61.0%. The other effects were 46.2, 28.0, 24.0, 16.8, 12.2 and 3.2 % under stirrup, sequential 1, sequential 3, PBW-Rope, combined 1 and combined 3 treatments, respectively.

1.4.1. Recovery of Boll Infestation % Means

Applying the mean of pbw trap catch to different treatments models (X), the expected boll infestation % (Y) could be calculated (Boll infestation Recovery %). The obtained boll infestation percentages were approximately the same as the actual ones.

1.4.2. Model Efficiency %

In order to Judge upon the model accuracy (Model Efficiency %), the recovery of boll infestation percentages were compared to the actual ones. The obained model efficiency % ranged from 98.47 % (Stirrup model) to 100.45 % (combined 1 model). These results gave some information about the accuracy of the models.

1.5. Expected (Y) when (X)= 8

As a trigger for pbw control, 8 pbw male moth / trap / week were applied to the model to get the correlated boll infestation %, as a second trigger. These expected boll infestation % triggers ranged from 2.16 % (stirrup) to 8.12 % (Sequential 3). These expected boll infestation triggers are shown in Fig. (1) under different treatments.

2- Different weekly Inspections

Results of this study and its statistical analysis by SAS software, are shown in Table 2 and illustrated in Fig. 2. The following values are shown:

2.1. Regression Value (b)

The highest regression value was that of the overall model (b = 0.38). The lowest regression value was that of week 7 (Aug. 30, the 1st week after the 5th spray). The other six inspections in weeks had regression values that lied between the two treatments mentioned before.

2.2. Relative Spray Efficacy %

Based on the highest b value, shown under the overall model, other inspection regression values could be arranged relatively to the overall value. Thus, the highest spray efficacy % was that of week 7 (-197.368 %). The lowest spray efficacy % was that of the 4th inspection (week 4, the 2nd week after the 3rd spray, -31.58 %).

2.3. The correlation Analysis

2.3.1. The coefficient and probability value

Comparison between correlation coefficient (r) and the probability value (p), showed the only highly significant correlation was that of the overall model (r= 0.95, P = 0.001), the significant correlation was that of week 4 (Aug.9, the 2nd week after the 3rd spray (r = 0.79, P = 0.012). In the other weeks, the correlations were not significant.

2.3.2. The coefficient of determination

Comparison of the coefficient of determination between different inspection dates showed that the overall model had the highest coefficient of determination (0.9025). This means that the pbw trap catch affected boll infestation % by 90.25 %. The coefficient of determination of the 4th week (Aug. 9) come next (0.618). On the other hand, the rest of inspecion dates had coefficient of determination values between 0.012 (1.2%) and 0.166 (16.6%).

2.4.1. Recovery of boll infestation % mean

By applying the pbw trap catches of different inspection dates the expected boll infestation % were close to the actual values. The actval boll infestation percentages ranged from 1.22 % (week 2) to 10.3% (week 8), the expected boll infestation pecentages ranged from 1.23 % (week 2) to 10.275 % (week 8).

2.4.2. Model efficiency %

By comparing the expected boll infestation percentages to ther original ones, the model efficiency percentage ranged from 99.25% to 100.71%.

2.5. The expected (Y) when (X) = 8

Applying the trigger of pbw trap catch (male moths / trap / week) to the different models, a series of boll infestation percentages in different inspection dates had been obtained. This series ranged from 1.12% (week 1) to 13.51 % (week 7).

DISCUSSION

From the statistical analysis of the data cetain points can be concluded:

1- The regression value "b"

The higher the regression value (slope) , the higher the expected (X) value calculated from (Y) values. The lower the regression value, the more effective the control measure is. Positive b value means positive proportion and negative b value means negative proportion. The 1st inspection after every spray had a negative b value, and had also a negative correlation coefficient. The 2nd inspection after every spray had a positive b value, and had also a positive correlation coefficient. The overall b value was positive, and also the correlation coefficient.

2- Relative efficacy

Comparison to the conventional insecticide treatments, other treatments reduced the potential of 1 male moth to cause boll infestation by a range from 18.64 % to 89.83 %. Compared to the overall model, almost every treatment reduced the potential of 1 male to increase boll infestation. In the 1st week after spray, the reduction was > 100% , while in the 2 nd week after spray the reduction was < 100%. These results demonstrated the initial effect of the control measure.

3- The correlation coefficient and prob. value

Under different control programs, the correlation coefficient (r) and (P) values were significant only where no two successive pheromone treatments were applied. This is because treatment in this case was suppressive (Sequential 2, combined 2 and insecticide treatments). When there were 2 successive pheromone treatments (Sequential 1 and 3, combined 1 & 3 or a long lasting pheromone treatment as PBW - Rope), the correlation coefficient and prob. values were not significant, because treatments in these cases were mating disruption. In the suppression technique, just after spray, the correlation was negative and thereafter was positive. In the disruption mating technique although the trap catches were almost zero, there were some occupational matings and consequently rates of boll infestation. The correlation was therefore not significant for r and prob. values.

4. The Coefficient of determination

Significant correlations were indicated only with high coefficient of determinations. Only the suppression techniques that had high coefficient of determination (0.757, 0.64 and 0.61). In the different inspections, the significant correlations were those that reflected high coefficient of determinations (in the overall = 0.9025 and in the 4 th week = 0.618).

These results indicated that under different treatments, the effect of trap catches significantly affected boll infestations only under the different suppression techniques. With season advance, trap catches significantly affected boll infestations in the mid season model and in the overall model only. This is due to the fact that there are many other factors that affect this relationship. Some of these factors are the sex ratio, fertility, natural mortality, predation, parasitism, insect life span, heat unit accumulation, flowering curve, boll maturity, and pbw diapause at late season.

It is suggested here, that it could not be possible to use the overall model for forecasting boll infestation percentages but the appropriate time model. It is important to use such models to trigger control action against different pest insect species.

Table (a) . Different treatments. insecticides used and spray numbers and intervals.

Treatment	Spray I	Spray II	Spray III	Spray IV	Spray V
	Jul. 1	Jul. 15	Aug. 1	Aug. 15	Aug. 29
1- Sequantial 1	{Profenofos+ Chlorofluazuron}	Gossyplure	Gossyplure	{Chlorpyrifos+ diflubenzuron}	Profenofos
2- Sequantial 2	Gossyplure	Cypermethrin	Gossyplure	{Chlorpyrifos+ diflubenzuron}	Chlorpyrifos
3- Sequantial 3	Gossyplure	Gossyplure	Thidoicarb	Cypermethrin	Profenofos
4- Sequantial 1	{Gossyplure/ [Profenofos+ Chlorofluazuron]}	Gossyplure	Gossyplure	Thidoicarb	Chlorpyrifos
5- Sequantial 2	Gossyplure	{Gossyplur/ Cypermenthrin}	Gossyplure		Profenofos
6- Sequantial 3	Gossyplure	Gossyplure	{Gossyplure/ Thiodicarb }	{Chlorpyrifos+ diflubenzuron}	Profenofos
7- Sequantial 1	Gossyplure	Gossyplure	Gossyplure	{Chlorpyrifos+ diflubenzuron}	Chlorpyrifos
8- Sequantial 2	Long	Lasting	Gossyplure	Thiodicarb	Chlorpyrifos
9- Sequantial 2	{Profenofos+ chlorfluazuron}	Cypermethrin	Thiodicarb	{Chlorpyrifos+ diflubenzuron}	Profenofos

Table 1 . Different models. correlation analysis, recovery, and model efficiency for different chemical treatments.

Treatments	Treatments Means					Linear regression model	"b" (2)	Relative treatment efficacy (3)	correlation analysis			r-Square	Relative boll inf.% Means (8)	Model efficiency (9)	Expected Y when X = 8 (10)
	Trap Catch			Infestation %					r	prob.					
	Mean (1)	(X)	Stdev	(X)	Stdev				(4)	(5)	(6)	(7)			
1- Sequantial 1	21.5	7.87	9.36	5.73	5.32	Y=3.13+0.28 X	0.28	-52.54%	0.53	0.177		0.28	5.32	99.07	5.38
2- Sequantial 2	43.0	4.12	5.82	5.37	3.35	Y=3.40+0.48 X	0.48	-18.64%	0.78	0.019	*	0.61	5.38	100.09	7.24
3- Sequantial 3	18.0	3.37	7.46	7.87	6.62	Y=4.65+0.44 X	0.44	-25.42%	0.49	0.210		0.24	7.84	99.62	8.12
4- Sequantial 1	34.0	21.8	11.96	6.62	5.73	Y=3.03+0.17 X	0.17	-71.19%	0.35	0.400		0.122	6.65	100.45	4.36
5- Combined 2	21.0	12.3	12.39	4.00	5.53	Y=0.77+0.39 X	0.39	-33.89%	0.87	0.005	**	0.757	3.98	99.50	2.35
6- Combined 3	32.5	6.75	7.67	3.00	2.45	Y=2.61+0.06 X	0.06	-89.83%	0.18	0.660		0.032	3.015	100.38	3.09
7-Insecticides	23.5	3.25	4.62	2.75	3.41	Y=0.83+0.59 X	0.59	0	0.80	0.017	*	0.64	2.75	100.00	5.55
8- Stirrup	18.0	12.2	11.68	2.62	1.78	Y=1.36+0.11 X	0.11	-81.35%	0.68	0.062		0.462	2.58	98.47	2.16
9- PBW-Rope	37.0	9.62	14.32	5.50	4.53	Y=4.25+0.13 X	0.13	-77.97%	0.41	0.310		0.168	5.45	99.09	5.24

1- Mean of trap catches two weeks before modeling.
2- b = (Regression value).
3- Relative treatment efficacy = treatment) - b (insecticide) / b (insecticide) *100.
4- r = correlation coefficient
5- Probability value.
6- * = Significant ** = Highly significant.
7- r; Square = coefficient of determination.
8- Recovery of boll infestation %. when applyingmeans of trap catches to the model
9- Efficiency % = (Recovery of boll infestation % true mean of infestation %) *100
Trigger for treatment.

Table 2 . Different models. correlation analysis, recovery, and model efficiency for different inspections.

Treatments	Treatments Means				Linear regression model	Regression Value "b"	Relative Spray efficacy (1)	correlation analysis			r-Square	Relative boll inf.% Means (6)	Model efficiency (7)
	Trap Catch		Infestation					r	prob.				
	(X)	Stdev	(Y)	Stdev				(2)	(3)	(4)	(5)		
1- Spray 2 Jul. 16 (week1)	2.78	4.17	1.44	1.71	Y=1.62+0.065 X	-0.065	-117.105%	-0.15	0.69		0.022	99.93	1.12
Jul. 23 (week2)	1.22	1.64	1.22	1.09	Y=1.08+0.12 X	0.12	-68.42%	0.18	0.65		0.03	100.49	2.04
II- Spray3 Aug.2 (week3)	6.78	8.39	2.56	1.77	Y=2.72+0.025 X	-0.025	-165.789%	-0.11	0.780		0.012	99.61	2.52
Aug.9(week 4)	3.00	5.74	2.67	1.93	Y=1.87+0.26 X	0.26	-31.58%	0.79	0.012	*	0.618	99.25	3.95
II- Spray4 Aug.16 (week 5)	7.11	10.95	6.00	5.38	Y=7.42+0.20 X	-0.20	-152.632%	0.407	0.277		0.166	99.96	5.82
Aug.23 (week6)	9.67	4.58	7.00	5.10	Y=5.10+0.20 X	0.2	-47.36%	0.176	0.649		0.031	100.48	6.77
IV- Spray5 Aug30 (week7)	17.89	8.3	9.78	6.8	Y=16.47+0.37 X	-0.37	-197.36%	-0.457	0.216		0.209	100.71	13.51
Sep.6 (week8)	27.11	9.07	10.3	5.91	Y=6.48+0.14 X	0.14	-63.16%	0.218	0.573		0.0476	99.46	7.6
Overall	10.77	8.81	4.21	3.28	Y=0.11+0.38 X	0.38	0	0.95	0.0001	***	0.9025	99.75	3.15

1- = (b (week)-b (overall) / b (overall)* 100
2- r= Correlation Coefficient
3- Probability Value
4- * = Significant ** = Highly significant
5- r - Square = Coefficient of determination.
6- Recovery of boll infestation % when applying means of trap catches to the model.
7- = (Recovery of boll infestation % / true mean of infestation % *100.
8- = A trigger treatment.

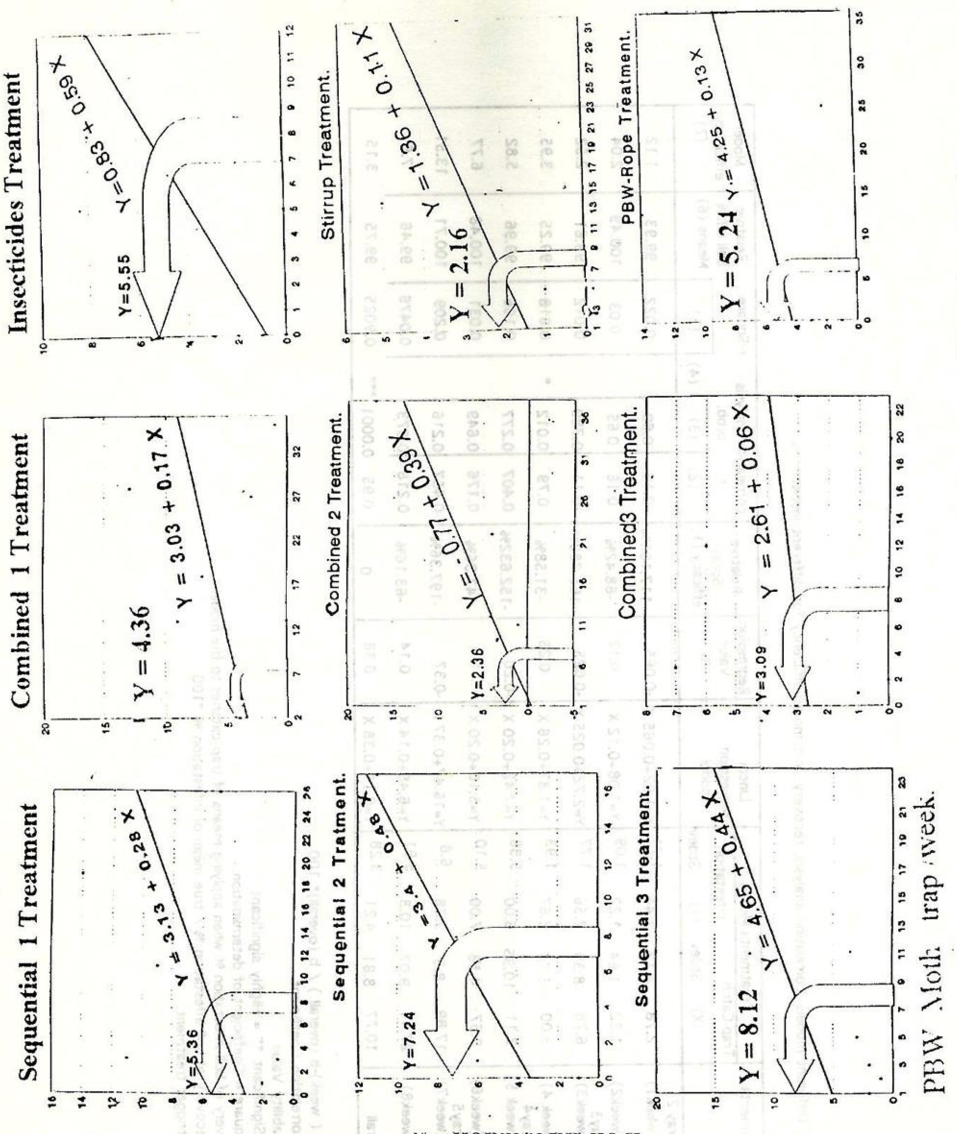

Fig 1. Linear regression, equation model, and expected (Y) when (X) = 8 under different inspection dates.

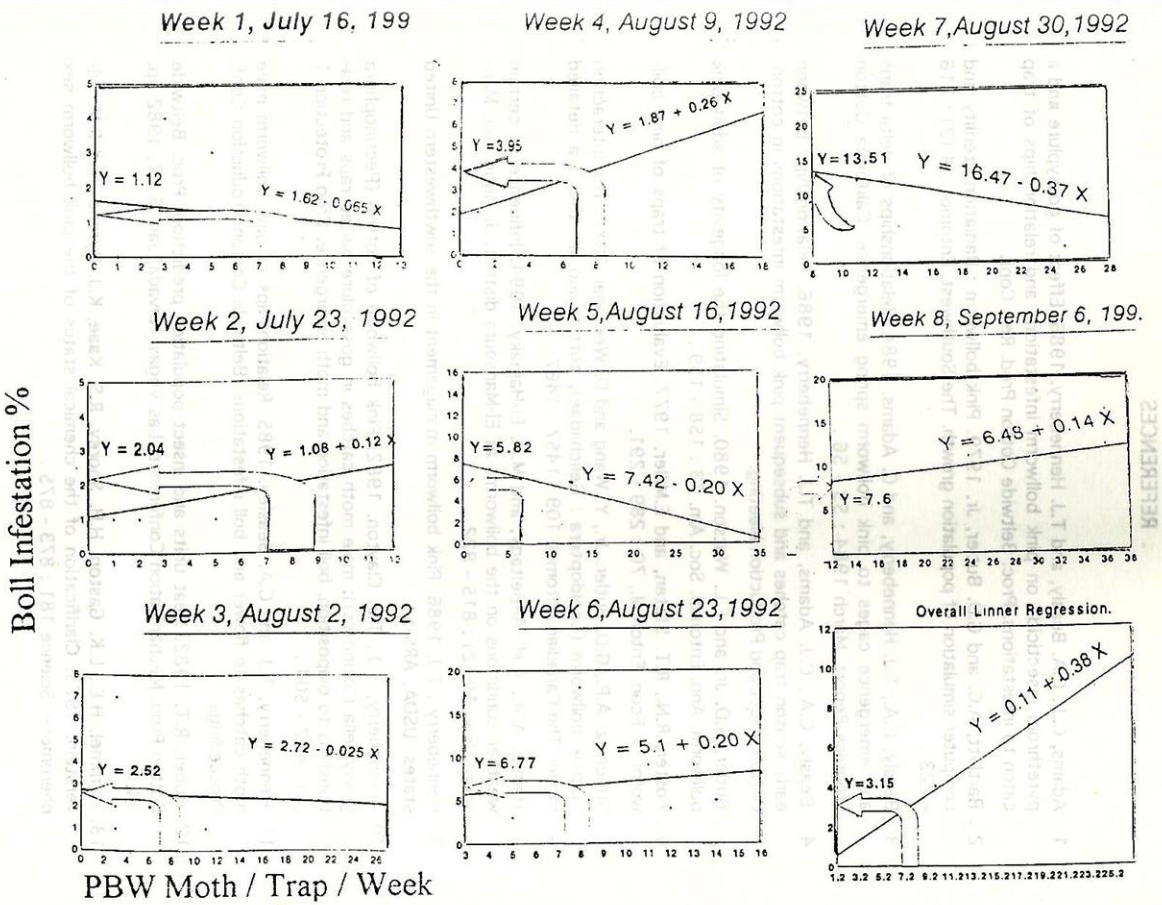

Fig 2. Linear regression, equation model, and expected (Y) when (X) = 8 under different inspection dates.

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المعادلات المختلفة لعلاقات مصائد الجاذبات الجنسية لدودة اللوز القرنفلية والاصابة فى اللوز الاخضر تحت ظروف مختلفة

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معهد بحوث وقاية النباتات - مركز البحوث الزراعية - الدقى - مصر .

تعتبر دودة القرنفلية أخطر آفة مدمرة لمحصول القطن فى جميع مناطق زراعة القطن فى العالم . ان التنبؤ بحركة وتعداد فراشات دودة اللوز القرنفلية باستخدام مصائد الجاذبات الجنسية (الفيرومونات) تعتبر ضرورة حتمية لتوجيه عملية المكافحة الكيميائية . إن العلاقة بين تعداد الفراشات (الذكور) فى المصائد والنسبة المئوية للإصابة فى اللوز يكون لها أهمية قصوى فى هذا المجال .

تحت ظروف ٩ معاملات مختلفة (فيرمونات) / او مبيدات فى ٣ تتابعات مختلفة و ٣ مخاليط مختلفة) تم تحديد المعادلات الخطية للإنحدار بين متوسط تعداد الذكور فى المصيدة (عامل مستقل) وبين متوسط النسبة المئوية للإصابة فى اللوز الأخضر (عامل تابع). وجد ان كل برنامج مكافحة له معادلة الانحدار الخطى الخاصة به وكذلك تختلف هذه المعادلة تحت ظروف المعاملة الواحدة بين أول الموسم ، وسط الموسم ، آخر الموسم . كذلك تم تحديد معادلة الانحدار الخطى الكلية.

كانت النسبة المئوية المتوقعة للإصابة فى اللوز الأخضر (المحسوبة من معاملات الانحدار الخطى) تحت ظروف المكافحة المختلفة تقع فى مدى ضيق جدا بالنسبة للنسبة المئوية للاصابة الحقيقية فى الحقل.