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A new formula for evaluating the effectiveness of insecticides against cotton bollworm under Egyptian conditions, instead of the Henderson and Tilton (1955) formula

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Abstract:

Bollworms , pink bollworm *Pectinophora gossypiella* (Saud.) (Lepidoptera: Gelechiidae) and spiny bollworm *Earis insulana* (Boisd) (Lepidoptera: Noctuidae), are the main cotton insect pests in Egypt. Too many insecticides from different insecticide groups are applied against it. The protocol of estimating insecticide efficacy against it and many other insect pests depends on the formula of Henderson and Tilton (1955), which needs to have a control area (Untreated area) equals to the area of one insecticide treatment , which is four cotton feddans (Acres), to calculate the reduction percentages in bollworms infestation percent after applying each insecticide treatment. Because of this condition is impossible and is not applicable (Because the financial costs of the losses of these untreated areas are about 40 thousand Egyptian bounds), it's recommended to apply the present formula, which derived from experimental data and it does not depend on the presence of untreated area, but it depends on the initial bollworms infestation percentages before applying for the insecticide treated program, to calculate the reduction percentages in bollworms infestation percent. The application of this formula solves a lot of insecticide application problems in the estimating insecticide efficacy protocol and gives acceptable and logical data which could be beneficial when its results are applied in the cotton fields.

Introduction.

Over 1990s, the global pesticide sale remained relatively constant, between 270 to 300 billion dollars, of which 44% were herbicides, 29% were insecticides, 21% were fungicides/bactericides, and 6% the others. Over the period 2007 to 2008, herbicides ranked the first in three major categories of pesticides: insecticides, fungicides/bactericides, herbicides (Zhang *et al.*, 2011). World pesticide expenditures totaled more than $35.8 billion in 2006 and more than $39.4 billion in 2007. Expenditures on herbicides accounted for the largest portion of total expenditures (Approximately 40%), followed by expenditures on insecticides, fungicides, and other pesticides, respectively. Total expenditures increased in 2007 due to increased spending on all pesticide types (Grube *et al.*, 2011).

Global demand for pesticides will rise 2.9 percent annually to 2014, this study analyzes the $45 billion world pesticide industry (Anonymous, 2010). Bakr (2013) mentioned that, efficacy of pesticides percentages can be calculated and corrected according to Abbott (1925) , Henderson and Tilton (1955) , Schneider-Orelli or Sun-Shepard Pǖntener (1981) formulas. These formulas calculate corrected efficacy % in pesticide trials. The selection of appropriate formula is depending on two factors: 1.Trial condition (Infestation or population stability and homogeneity). 2.The handled data (Live individuals or mortality %).

Although Abbott's (1925) formula was a convenient descriptive statistic for calculating the percentage control obtained between the Core Treatment versus Control areas, modified or additional analytical procedures also were used by research teams at individual sites. Henderson and Tilton's (1955) formula provides a similar metric for measuring percentage control, but by quantifying changes in tick density between baseline and subsequent sampling times. It can be used to determine treatment effects between any two sampling periods (Pound *et al.*, 2009).

In this study the present formula is compared to Henderson and Tilton's (1955) formula for calculating and correcting insecticides efficacy percentages against bollworms in commercial cotton fields in Egypt.

Materials and methods

This study was carried out at, Kom Isho village, Kafer Aldawar district, Bahira Governorate, , Egypt, whereas 18 commercial cotton fields were chosen 17 areas for 17 different insecticide treatments, and one as an untreated (Control) area, each area contained 4 cotton acres. Three insecticide applications (Each every 15 days) were conducted with the same insecticide, in three successive applications (29/8, 11/9, and 25/9/2012, respectively). The insecticides used, formulation, concentrations, and rates of applications are shown in Table (1).

Table (1): Applied insecticides against bollworms, formulations, concentrations, and application rates.

Application #	Insecticide (Trade name)	Insecticide (Common name)	Con. % and formulation	Application rate / Acre
I- Organophosphorus				
1	Helpan	Chlorpyrifos	48% - Ec	1 L
2	Dorsell	Chlorpyrifos	48% - Ec	1 L
3	Chlorzid	Chlorpyrifos	48% - Ec	1 L
4	Pesteban	Chlorpyrifos	48% - Ec	1 L
5	Pyrofos	Chlorpyrifos	48% - Ec	1 L
6	Chlofet	Chlorpyrifos	48% - Ec	1 L
7	Silian	Profenofos	72% - Ec	750 ml
8	Teliton	Profenofos	72% - Ec	750 ml
II- Pyrethroids				
9	Lampada Star	Lambdacyhalothrin	5% - Ec	375 ml
10	Kafrothrin	Deltamethrin	2.5% - Ec	750 ml
11	Lamdathrin	Lambdacyhalothrin	5% - Ec	375 ml
12	Decies	Deltamethrin	2.5% - Ec	350 ml
13	Agristar	Lambdacyhalothrin	5% - Ec	375 ml
14	Pylarmada	Lambdacyhalothrin	5% - Ec	750 ml
15	Demand	Deltamethrin	2.5% - Ec	400 ml
16	Alfazed	Alpha cypermthrin	10% - Ec	250 ml
III - Carbamates.				
17	Newmell	Methomyl	90 % - SP	300 gm

Seventy two (72) green cotton boll samples (14 -21 day old, four randomized samples from each treatment, each contained 100 green boll) were weekly collected from the 18 cotton fields in six successive investigations , beginning from 29/8/2012 , and up to 3/10/2012, transferred to the laboratory, whereas subjected to investigations, calculating and recording boll infestation percentages.

Two formulas were used to calculate the reduction in boll infestation percentages caused by different insecticide application, these formulas are:

Henderson and Tilton's (1955) formula:

$$\text{Reduction \%} = \left(1 - \frac{(\text{B.I. \% in Co. before treatment}) \times (\text{B.I. \% in T after treatment})}{(\text{B.I. \% in Co. after treatment}) \times (\text{B.I. \% in T before treatment})}\right) * 100$$

Where : B.I. % = boll infestation % , T = treated , Co. = control

The present formula :

$$\text{Reduction \%} = \left(\frac{(\text{B.I. \% in T. before treatment}) - (\text{B.I. \% in T. after treatment})}{(\text{B.I. \% in T. after treatment})}\right) \times 100$$

Where : B.I. % = boll infestation % , T. = treated .

Results and discussion

Data showed in Table (2) summarized the weekly averages of boll infestation percentages pre and post the above mentioned insecticide treatments. These data include the bollworm infestation percentages recorded from the untreated area (Control).

Table (2) : Averages of weekly bollworms infestation % .

Treatment #	Averages of weekly bollworms infestation %					
	Pre Treatment	Post Treatment				
	1	2	3	4	5	6
1	16	7	7	3	5.5	6.25
2	12	5.5	6.5	1.75	6.75	11.75
3	15	3.5	3.5	1.5	6.25	4.25
4	14.5	5	5.5	2.25	4.75	3.25
5	32	11.5	11.5	1.75	3.5	4.5
6	30.5	4.5	4.5	2.5	5.5	6.75
7	26.5	4.5	4.5	0.75	4.75	8
8	26	4	4	0.75	10.25	2.25
9	17.5	5.5	5.5	0.75	2.75	3.25
10	17.5	3	3	2.25	4	0.75
11	25	5.5	5.5	1.5	1.25	1.75
12	22	7	7	1	1.5	1.5
13	12	4.5	4.5	2	2	3
14	12.5	2	2	2.5	1.75	2.25
15	9	15.5	17	1	1.75	0.75
16	14	6	5	1.25	1.5	1
17	8.5	4.5	5	0.75	1.5	1.5
18	16	4	4	0.25	0.75	0.25

Data in Table (3) showed the negative bollworms reduction percentages obtained after applying Henderson and Tilton's (1955) formula in calculating the reduction percentages of bollworms infestation percentages (Table 2) after the application of the above mentioned insecticide applications .

Table (3) : Reduction percentages in boll infestation % according to Henderson and Tilton's (1955) formula .

Treatment #	Weekly bollworm investigations					
	1	2	3	4	5	Average boll infestation Red. %
1	-174.0	-99.0	-684.7	-60.1	-339.9	-271.5
2	-182.3	-117.2	-429.8	-127.6	-521.2	-275.6
3	-92.3	-99.0	-684.7	-137.9	-203.0	-243.4
4	-136.9	-109.0	-653.5	-69.4	-204.3	-234.6
5	-142.8	-99.0	-242.5	-65.7	-384.7	-186.9
6	-58.0	-99.0	-887.9	-72.3	-367.2	-296.9
7	-66.9	-99.0	-265.7	-210.1	-504.3	-229.2
8	-60.5	-99.0	-299.0	-454.6	-64.9	-195.6
9	-124.7	-99.0	-217.2	-121.2	-353.5	-183.1
10	-67.6	-99.0	-1,199.0	-58.3	-55.3	-295.8
11	-87.0	-99.0	-435.4	-26.8	-419.0	-213.4
12	-126.3	-99.0	-227.6	-49.0	-299.0	-160.2
13	-149.0	-99.0	-710.1	-32.3	-449.0	-287.9
14	-63.0	-99.0	-1,999.0	-22.3	-384.7	-513.6
15	-687.9	-108.7	-93.1	-57.3	-127.6	-214.9
16	-170.4	-82.3	-399.0	-39.0	-199.0	-178.0
17	-210.8	-110.1	-239.0	-65.7	-299.0	-184.9

Data in Table (4) showed the positive bollworms reduction percentages obtained after applying the present formula in calculating the reduction percentages of bollworms infestation percentages (Table 2) after the application of the above mentioned insecticide applications .

This paper does not discuss the efficacy of different insecticides applied against bollworms, but it discusses the viability of using the formula here instead of Henderson and Tilton's (1955) formula in these different cases :

1. In calculating the reduction in infestation % after any treatment (Herbicide, insecticide, bactericide fungicide or any other pesticide), in any crop and against any pest rather than using Henderson and Tilton's (1955) formula, which uses in calculating the reduction in insect population (Not infestation %) .
2. In a case of the absence of untreated area (Control).
3. In a case of a farmer applied insecticide to the untreated area for a commercial reasons (To gain more benefits) , so fare the infestation in the untreated (Control) is equal or smaller than in the treated areas, because this'll cause a negative reduction % not positive ones .
4. In a case of getting illogical data from the untreated area or data loss for any reason or another.

Table (4) : Reduction percentages in boll infestation % according to the present formula .

Treatment #	weekly reduction in bollworm infestation %					
	1	2	3	4	5	Average boll infestation Red. %
1	56.3	56.3	81.3	65.6	60.9	64.1
2	54.2	45.8	85.4	43.8	2.1	46.3
3	76.7	76.7	90.0	58.3	71.7	74.7
4	65.5	62.1	84.5	67.2	77.6	71.4
5	64.1	64.1	94.5	89.1	85.9	79.5
6	85.2	85.2	91.8	82.0	77.9	84.4
7	83.0	83.0	97.2	82.1	69.8	83.0
8	84.6	84.6	97.1	60.6	91.3	83.7
9	68.6	68.6	95.7	84.3	81.4	79.7
10	82.9	82.9	87.1	77.1	95.7	85.1
11	78.0	78.0	94.0	95.0	93.0	87.6
12	68.2	68.2	95.5	93.2	93.2	83.6
13	62.5	62.5	83.3	83.3	75.0	73.3
14	84.0	84.0	80.0	86.0	82.0	83.2
15	-72.2	-88.9	88.9	80.6	91.7	20.0
16	57.1	64.3	91.1	89.3	92.9	78.9
17	47.1	41.2	91.2	82.4	82.4	68.8

The present formula is very simple, easy to be calculated and applicable that any farmer who cultivated any crop and has applied any control action (Biologically, physically, or chemically " as a part of integrated pest management (IPM)) can apply it to know the efficacy of this control action in his own farm however it's a small or large one . By this way farmers can manage their control action easily and scientists and experts can get more reliable data successfully. The most valuable advantage of the formula here is that: it does not have any financial costs , while the application of all other formulas causes financial losses and costs for a very simple reason, The present formula does not need any untreated areas (Control), and does not need any control samples, it depends on the data of the pre treatment to compare with that of the post treatment to calculate the reduction percentage for any control action under any conditions **.**

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