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Field Efficacy of Selected Insecticides against *Spodoptera littoralis*, Aphid Species and *Bemisia tabaci* on Stevia Plants

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ABSTRACT

The field efficiency of some insecticides were evaluated against major insect species of stevia plants. The obtained results demonstrated that all of the insecticide treatments significantly reduced densities of tested insects compared to the untreated check. Average mean of reductions in *S. littoralis* larvae were 58.96, 69.28, 71.70 and 83.59% for leufenuron, indoxacarb, emamectin benzoate and methoxyfenozide respectively in 2021 season. As, 62.71, 75.24, 78.16 and 86.51% for the previous insecticides, respectively in 2022 season. Statistical analysis proved that significant differences among these insecticides during the two seasons. Regarding *B. tabaci*, overall mean of reductions were 68.42, 81.11, 81.42 and 81.14% to abamectin, Malathion, dinotefuran and lambada-cyhalothrin, respectively in 2021 season. While, the means were 67.03, 81.96, 83.80 and 82.43% for the later insecticides during 2022 season. In such concern, the means were 64.30, 81.22, 82.63 and 82.88% for abamectin, Malathion, dinotefuran and lambada-cyhalothrin, respectively in 2021 season. Whereas in 2022 season, the means were 66.12, 81.97, 83.11 and 81.89% for these previous insecticides against aphid species populations.

Keywords: insecticides, insect species, *S. littoralis*, stevia plants

1. Introduction

Stevia rebaudiana Bertoni (Family: Asteracea) has been widely planted in the world for the sweet diterpene glycosides that are mainly contained in its leaves (Abou-Arab *et al.,* 2010). Stevia plants contain eight glycoside compounds and stevioside is the most abundant one. The extracts of these compounds may up to 300 times sweeter than sucrose (Tanaka, 1997). *S. rebaudiana* has been used throughout the world as a noncaloric biosweeter owing to its two major thermostable phytoconstituents - namely, stevioside and rebaudioside- which have recently been added to the European union list of permitted sweeteners. A number of countries across the globe, such as Japan, China, Malaysia, Taiwan, Australia, Korea, Egypt, etc. have approved the use of *S. rebaudiana* based sweeteners in foods and beverages (Nadaf and Naikwadi, 2022). Stevia products are approved in more than 100 countries and about 5 billion consumers have access to stevia products. In Egypt, Ministry of Agriculture and Land Reclamation is planning to expand the cultivated stevia area in the coming decades to reduce imports and if possible, to achieve self-sufficiency of sugar. The total area planted with stevia reached 50000 feddans sponsored by the private companies such as Stevia International Company for Agricultural and Industrial projects and Glyco Medical Industries (Bazazo *et al*., 2012). Khalil *et al.* (2015) indicated that stevia is cultivated in different places of the world, it is expected that in the Egyptian agriculture environment one feddan of stevia may produce up to 400kg of stevia sugar annually. *S. rebaudiana* has great potential as a cash crop for farmers (Stevia: rom niche, 2013). Concerning the insect pests on stevia plants, Anonymous (2010) reported that stevia plants are vulnerable to a host of insects. Bazazo

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et al. (2013) indicated that phalacrid species (Cleoptera) and *Syngrapha circumflexa* L. (Noctuidae) are pests to stevia plants.

Aphids, white flies, mites, thrips, grass hopper, mealy bugs, cut worm, *Nezara viridula*, *Spodoptera spp*. And Cicadellidae are the dominat insects in stevia fields all over the world (Thomas, 2000 ; Midmore and Rank 2002 ; Anonymous, 2004 ; Megeij *et al*., 2005 and Lowery, 2017). Mekonnen and Manahlie (2017) showed that insect pests are major limiting factors for the cultivation and production of stevia in many agro-ecologies in Ethiopia they recorded termite (Isoptera) + aphids (Homoptera) + scale insects (Hemiptera) + plant bug (Miridae) are dominate insects on stevia plants. Final *et al.,* 2015 surveyed 8 species of noctuids (Lepidoptera) insects infested stevia plants. *Helicoverpa armigera* Hbn and *Chloridae peltigera* Schiff are dominant pests to this crop in USA. Anonymous (2010) noted that aphids, thrips and white flies can become a serious problem on stevia in greenhouses, which could significantly impact transplant production. Research in Kansas indicated that rabbit and deer feeding was not a problem in their stevia plots. Ye *et al.* (2013) demonstrated that onion thrips was the harm species of *S. rebaudiana* in China. Kostjukov *et al.* (2015) reported that *Helicoverpa armigera* and *Heliothus peltigera* are dangerous pests of stevia in Russian fields. Also, Lowery (2017) recorded that six insect orders were observed on stevia plants. Hymemoptera were the most numerous, followed by Diptera, Hemiptera, Coleoptera, Lipidoptera and Orthoptera in Tennessee fields. *Spodoptera spp.* are dominant insects. Finally, Bazazo *et al*. (2013) demonstrated that insect pests can reduce the leaf weight of stevia by 10.20%, which means a considerable loss in the plant weight. Also, they reduce stevioside concentration in leaves of stevia.

2. Materials and Methods

Seedling of stevia plants (Spanti variety) were obtained from sugar crops Research Institute-Giza, Egypt. Seedlings were planted on 15 March during the two seasons 2021 and 2022. The two field experimental were carried out at Baltim region, Kafr El-Sheikh Governorate. Four insecticides plus control treatment were arranged in completely randomized block design (CRBD). Each insecticide was about 168m^2 divided into four replicates. The insecticides were sprayed by knapsack sprayer (20 L). The first experimental area was assigned for *Spodoptera littoralis*, whereas the second experimental area was assigned for *Bemisia tabaci* and aphid species.

Date of spraying was on 15 May during the two seasons. Before spraying, 40 plants (10 /replicate) were inspected by visual examination for counting insect individuals in all insecticides and control. After spraying, the same numbers of plants were inspected in all insecticides and control. Conventional insecticides were recorded after one, 7 and 10 days. As, alternatives ones were recorded after three, 7 and 10 days. To calculate the percentages of reduction Henderson and Tilton (1955) was used.

Table 1: Common name, trade name and the rate of application for each insecticides against *Spodoptera littoralis* larvae during 2021 and 2022 seasons.

Common name	Trade name	Rate / fed.
Lufenuron	Geltaron 5% EC	160 cm^3
Indoxacarb	Aspir 30% WG	30 gm
Emamectin benzoate	Hishera 5.7% WG	80 gm
Methoxyfenozide	Hambein 24% SC	75 cm^3

Table 2: Common name, trade name and rate of spraying for each insecticide against *Bemisia tabaci* and aphid species throughout 2021 and 2022 seasons.

Common name	Trade name	Rate / fed.
Abamectin	Gold 1.8% EC	80 cm^3
Malathion	Malathion 57% EC	300 cm^3
Dinotefuran	Rabator 20% SG	100 gm
Lambada-cyhalothrin	Valopera 10% EC	100 cm^3

Statistical analysis

All statistical analysis were performed using analysis of variance (ANOVA) technique by means of SPSS computer software package. The treatment means were compared using Duncan multiple range test (Duncan, 1955). Reductions in insects populations were calculated by using Henderson and Tilton formula (1955).

$$\text{Reduction \%} = 1 - \left\{\frac{N.Co.before}{N.Co.after} X \frac{N.T.after}{N.T.before}\right\} X\ 100$$

Thus the current experiments were done during 2021 and 2022 seasons at Baltim to investigate the following items:

1. Efficacy of various insecticides groups on *Bemisia tabaci* and aphid species populations.
2. Efficiency of different insecticides groups on *Spodoptera spp*. (*Spodoptera littoralis* and *Spodoptera exigua*).

3. Results and Discussion

3.1. Effect of different insecticides groups on certain stevia insect pests:

3.1.1. On the cotton leafworm, *Spodoptera littoralis* larvae

Data in Table (3) show that overall mean of reduction in *S. littoralis* larvae population after 10 days post treatment were 58.96, 69.28, 71.70 and 83.59% for lufenuron, indoxacarb, emamectin benzoate and methoxyfenozide, respectively. Mean of larvae/ 10 plants decreased from 7.50 to 2.50 larvae/10 plants for lufenuron after 10 days. Also, the mean of larvae suppressed from (7.25 to 1.25), (7.00 to 1.00) and (7.75 to 1.00) for indoxacarb, emamectin benzoate and methoxyfenozide, respectively. Statistical analysis proved that significant differences among the certain insecticides during 2021 season.

Table 3: Impact of different insecticides on *S. littoralis* under field conditions during 2021 season.

Insecticides	Before spraying Mean	After spraying / day / %						Overall Mean Of reduction*
		3		7		10		
		M.	Red.	M.	Red.	M.	Red.	
Lufenuron	7.50	5.25	34.51	4.00	61.33	2.5	81.04	58.96[a]
Indoxacarb	7.25	4.25	45.16	2.75	72.50	1.25	90.19	69.28[b]
Emamectin benzoate	7.00	4.00	46.54	2.25	76.69	1.00	91.87	71.70[c]
Methoxyfenozide	7.75	2.5	69.82	1.25	88.30	1.00	92.66	83.59[d]
Control	7.25	7.75	----	10.00	-----	12.75	-----	---------

*The Duncan test at level of 5% probability was applied.

In 2022 season, Table (4) clarify that overall mean of reductions in *S. littoralis* larvae numbers were 62.71, 75.24, 78.16 and 86.51% for the previous different insecticides, respectively. Moreover, mean of larvae/10 plants suppressed from 8.25 larvae/ 10 plants (before spraying) to 2.75 larvae for lufenuron post 10 days. In such concern, the mean of larvae numbers eliminated from (8.50 to 1.00), (9.00 to 1.25) and (8.75 to 1.25) for indoxacarb, emamectin benzoate and methoxyfenozide, respectively. Statistical analysis showed that significant differences among these insecticides.

These results indicate that methoxyfenozide was the efficient insecticide in controlling *S. littoralis* larvae during the two seasons. The second rank was emamectin benzoate followed by indoxacarb. As, the insecticide, leufenuron was the least efficient as compared to the three insecticides during the two seasons.

Table 4: Impact of various insecticides groups against *S. littoralis* larvae under field conditions during 2022 season.

Insecticides	Before spraying Mean	After spraying / day / %						Overall mean of reduction*
		3		7		10		
		M.	Red.	M.	Red.	M.	Red.	
Lufenuron	8.25	5.75	42.50	4.50	64.62	2.75	81.03	62.71[a]
Indoxacarb	8.50	5.00	51.47	2.50	80.96	1.00	93.30	75.24[b]
Emamectin benzoate	9.00	4.75	56.45	2.00	85.62	1.25	92.04	78.16[c]
Methoxyfenozide	8.75	2.25	78.78	1.50	88.90	1.25	91.87	86.51[d]
Control	8.25	10.00	-----	12.75	-----	14.50	-----	-------

*The Duncan test at level of 5% probability was applied.

3.1.2. On the white fly, *Bemisia tabaci* nymphs

In 2021 season, Table (5) indicate that the overall mean of reductions in *B. tabaci* individuals after 10 days post-treatment were 68.42, 81.11, 81.42 and 81.14% for the alternative insecticide abamectin, and the conventional insecticides, malathion, dinotefuran and lambada-cyhalothrin, respectively.

Mean of nymphs/ 10 plants decreased from 12.50 to 2.50 nymphs/10 plants after 10 days post spraying. Moreover, the mean of nymphs were reduced from (13.00 to 1.00), (12.75 to 1.25) and (12.50 to 1.25) for malathion, dinotefuran and lambada-cyhalothrin, respectively. Statistical analysis demonstrated that significant difference among the four insecticides.

Table 5: Reductions in *B. tabaci* nymphs due to certain insecticides on stevia plants, 2021 season.

Compounds	Before spray	After spray / day								Overall mean of reduction*
		1		3		7		10		
		M.	Red.	M.	Red.	M.	Red.	M.	Red.	
Abamectin	12.50	---	---	7.75	46.40	4.00	73.67	2.50	85.21	68.42[a]
Malathion	13.00	4.75	64.84	---	---	2.50	84.18	1.00	94.31	81.11[b]
Lambada-cyhalothrin	12.50	4.25	67.28	---	---	2.50	83.54	1.25	92.60	81.14[b]
Dinotefuran	12.75	4.50	66.03	---	---	2.25	85.48	1.25	92.75	81.42[b]
Control	12.75	13.25	---	14.75	---	15.5	---	17.25	---	---

*The Duncan test at level of 5% probability was applied.

In 2022 season, Table (6) results were obtained. Overall mean of reduction were 67.03, 81.96, 83.80 and 82.43% for abamectin, malathion, dinotefuran and lambada-cyhalothrin, respectively. In addition to, mean of nymphs, were decressed from (10.75 to 2.75), (11.50 to 1.25), (12.50 to 1.00) and (12.25 to 1.25) for the previous insecticides, respectively. Statistical analysis show that significant differences among the four insecticides.

These data proved that the conventional systemic insecticides were efficient in killing *B. tabaci* nymphs in comparison with the alternative insecticide (abamectin).

Table 6: Reductions in *B. tabaci* nymphs due to certain insecticides on stevia plants, 2022 season.

Compounds	Before spray	After spray / day								Overall mean of reduction*
		1		3		7		10		
		M.	Red.	M.	Red.	M.	Red.	M.	Red.	
Abamectin	10.75	---	---	6.00	47.53	3.75	72.67	2.75	80.91	67.03a
Malathion	11.50	3.75	69.34	---	---	2.25	84.67	1.25	91.89	81.96b
Lambada-cyhalothrin	12.25	4.00	69.30	---	---	2.25	85.61	1.25	92.38	82.43b
Dinotefuran	12.50	4.00	69.92	---	---	2.00	87.46	1.00	94.03	83.80b
Control	11.75	12.50	---	13.00	---	15.00	---	15.75	---	---

*The Duncan test at level of 5% probability was applied.

3.1.3 On the aphid species (Nymphs + adults)

In 2021 season, Table (7) recorded that the overall mean of reductions in aphid species populations were 64.30, 81.22, 82.63 and 82.88% for abamectin, malathion, dinotefuran and lambada-cyhalothrin, respectively. Mean of aphid individuals decreased from (12.75 to 3.00), (12.25 to 1.00), (12.75 to 1.25) and (12.50 to 1.00) for the previous insecticides, respectively. Statistical analysis demonstrated that significant differences between the alternative insecticide abamectin and the three conventional ones.

Table 7: Reduction in aphid species populations due to some insecticides on stevia plants, 2021 season.

Compounds	Before spray	After spray / day								Overall mean of reduction*
		1		3		7		10		
		M.	Red.	M.	Red.	M.	Red.	M.	Red.	
Abamectin	12.75	---	---	7.75	43.71	4.50	68.48	3.00	80.71	64.30a
Malathion	12.25	4.00	68.60	---	---	2.50	81.77	1.00	93.30	81.22b
Dinotefuran	12.75	3.75	71.71	---	---	2.25	84.24	1.25	91.96	82.63b
Lambada-cyhalothrin	12.50	3.50	73.07	---	---	2.50	82.14	1.00	93.44	82.88b
Control	12.50	13.00	---	13.5	---	14.00	---	15.25	---	---

*The Duncan test at level of 5% probability was applied.

On the other hand, data in Table (8) show that the overall mean of reductions were 66.12, 81.89, 81.97 and 83.11% for abamectin, lambada-cyhalothrin, malathion and dinotefuran, respectively. Also, mean of aphid populations/10 plants were reduced from (10.50 to 2.75), (10.75 to 1.00), (11.00 to 1.00) and (11.00 to 1.25), respectively in 2022 season. These findings clarified that the conventional insecticides; malathion, dinotefuran and lambada-cyhalothrin were efficient in controlling aphid species in comparison with the conventional insecticide (abamectin) throughout the two seasons.

These results are agreement with several authors such as Abdalla *et al.* (2005) concluded the three insecticides (lufenuron, chromafenozide and ecogen) are efficient in controlling of *Spodoptera spp.* larvae. Particularly against earlier larval stages of the cotton leafworm and able to contain the early infestation before outbreak resurgence. Also, Abdel-Rahim *et al.* (2009) showed that flufenoxuron increased the larval and pupal duration and decreased the pupation, adult emergence and fertility of the eggs produced by adult progeny of *Spodoptera littoralis*. In general, it was observed that emamectin benzoate was more effective in all the mentioned measured parameters.

Table 8: Reduction in aphid species populations due to some insecticides on stevia plants, 2022 season.

Compounds	Before spray	After spray / day								Overall mean of reduction*
		1		3		7		10		
		M.	Red.	M.	Red.	M.	Red.	M.	Red.	
Abamectin	10.50	---	---	5.75	50.71	4.00	67.65	2.75	80.02	66.12a
Lambada-cyhalothrin	11.00	3.25	71.71	---	---	2.25	82.63	1.25	91.33	81.89b
Malathion	10.75	3.50	68.82	---	---	2.00	84.20	1.00	92.90	81.97b
Dinotefuran	11.00	3.25	71.71	---	---	2.00	84.56	1.00	93.06	83.11b
Control	11.25	11.75	---	12.50	---	13.25	---	14.75	---	---

*The Duncan test at level of 5% probability was applied.

In another study, Korrat *et al*. (2012) indicated that after 3 days of the treatment, emamectin benzoate was the most effective insecticide against *Spodoptera littoralis*, followed by chorfluazuron and profenofos and finally spinosad which showed the lowest toxic effect. Moreover, Benelli *et al*. (2020) reported that *Stevia rebaudiana* is a medicinal plant of economic importance in the food market for the manufacture of natural sweeteners. The Eo insecticidal efficacy was evaluated against the aphid species. The Eo composition was dominated by sesquiterpenes, i. e. caryophyllene oxide (20.7%), spathulenol (14.9%), e-nerolidol (8.0%) and diterpenses, i.e. phytol (9.2%). The Eo was effective against aphid species. In such concern, Anonymous (2023) reported that many aphid species are difficult to distinguish from one another; however, management of most aphid species is similar. Chemical apply, synthetic pyrethroids like permethrin or conventional insecticides like imidacloprid, malathion and acephate. Regarding while fly (*B. tabaci*) both nymphs and adults damage plants by sucking the juices from new growth causing stunted growth, leaf yellowing and reduced yields. Plants become weak and susceptible to diseases. Chemical control by using dichlorovos imidacloprid or synthetic pyrethroids. Finally, Anonymous (2023) demonstrated that spray your stevia with a systemic insecticide that contains imidacloprid early in the morning. This is a commercial chemical that is non-toxic to humans and beneficial pollinators, but deadly to harmful insects like aphids. In the light of these findings, it is recommended to spray the highest efficient insecticide for obtaining the highest yield of stevia crop.

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