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A comparative study between some control programs of *Aphis gossypii* infesting squash plant under field conditions

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Abstract
The cotton aphid *Aphis gossypii* is a major insect pest infesting squash plant resulting in a huge loss in yield and quality to farmers. The objective of this study was to apply a biological and mix control programs on squash crop under field conditions, compared with insecticides to control *A. gossypii*. The treatments were conducted at El-Nubaria region, El Behiera, Egypt, during two seasons of nili squash plantation (2019&2020). Inspection was made once a week to determine the population density of Aphid. In the chemical treatment we used one of these pesticides (Buprofezin or Super alpha) first application of insecticides was done after one month of transplanting and subsequent applications were done at 15day intervals. In the mixed treatment, we used one of these pesticides (Buprofezin or Super alpha), *Beauvaria bassiana* and release the predator *Chrysoperla carnea* alternately every 15day intervals until end of the season. In the biological control, field trials were carried out to determine the efficacy of *C. carnea* and *B. bassiana* in alternative way at 15day intervals. General mean of reduction of Aphid was recorded in chemical control (87.25% and 58.5%) during season 2019 and season 2020, respectively. The estimated yield of squash crop post application of the treatments was significant by higher (4.848 & 4.572 ton/fed.) for chemical, followed by Mix (4.1064 & 4.020 ton/fed.) followed by bio (2.925.6& 3.8748 ton/fed.) Compared to (2.6172 & 2.7468 ton /fed.) for the untreated check for season of 2019 & 2020, respectively. According to our findings, the superior, efficient toxic impact of the tested treatment, a high benefit, and the greatest yield were obtained with the use of chemical control during seasons 2019 and 2020.

Keywords: squash, *Aphis gossypii*, biological control, *Chrysoperla carnea*, chemical control

Introduction

Squash (*Cucubita pepo* L.) is one of the most important and popular vegetable crop in the world. Squash's family is one of the largest families in the plant kingdom consisting of largest number of plant species supplying humans with edible products and useful fibers (Abd Elmohsen *et al*., 202) [1] Squash fruits had high nutritional values due to their high contents of carbohydrates, amino acids, vitamins and minerals. The cultivated area of squash was 22761 ha on small fields which are less than 1 ha (Refai & Hassan, 2019) [17]. The cotton aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae), which inflict severe damage on plants and is thought to be virus disease vectors, is one sucking insect pests that is particularly harmful to squash crops. (Embarak *et al*., 2020) [8] *A. gossypii* can decrease a plant's ability to photosynthesize by creating sugary honey dew, which hinders photosynthesis and causes wilt and plant death (Amine *et al*., 2022) [4] Aphids' high rate of reproduction and quick population growth are additional variables that lead to financial losses in crop yield and quality. (Güncan *et al*., 2006); Vasquez *et al*.,2006) [10]. Chemical insecticides are the major method used to control these nuisance insects, but their indiscriminate and excessive use has created problems with insecticide resistance and residue in addition to health risks (Elsanusi *et al*., 2020) [7]. Chemical pest control causes environmental damage, adverse effects on people, domestic animals, and natural enemies. Therefore, biological control is still a crucial part in managing insect pests. Due to the likelihood that vegetable harvests would be utilized as fresh foods, this is especially advised in vegetable plantations. The previous few years, in integrated for integrated pest management, the Ministry of Agriculture aims to use insecticides as little as possible. To preserve the natural balance, it is imported different predators, entomopathogenic fungi, *Beauvaria bassiana*, or microbial controls are ecofriendly and safe for life (El-Kareim *et al*., 2015) [6].

Many studies have been conducted about the use of biological, chemical, or botanical pesticides in the crop (Asim *et al*., 2017; Mahato, 2017) [13], but only a few have compared the effectiveness and profitability of both research approaches.

The aims of the present study were to evaluate using biological and mix control to control *A. gossypii* . Compared with a traditional insecticide application program during the nili squash plantation under field conditions. Determination of the efficacy of different treatments on squash yield. Studying the economic and profits of treatments to control aphid.

Material and methodes

1. Experimental location and design

The experiment was carried out under natural field conditions in the research farm at El-Nubaria research station (48 km south-west west Alexandria city) during two successive seasons of (2019&2020). The experiment was conducted in a Randomized Complete Block Design (RCBD) with four treatments each treatment was kirate of nili squash (*C. pepo*), variety, SAKATA (AZIAD HYBRID), and each treatment was replicated three times. Each treatment contained five rows of 60 m^2 (100 plants). Ten leaves were taken randomly/replicates of squash and continued weekly until the end of the season. The leaves were picked, put in paper bags, and transferred to the laboratory for examination using a stereo microscope to determine and record the different populations of *A. gossypii*. Sandy loam is the predominant soil type in the study region.

2. Insecticides and predator used

The chemical insecticide used in this study were Buprofezin (20cm/20L) Alpha-cypermethrin (Super Alpha® 10%EC) (25cm/20L) and the bio-pesticide *Beauvaria bassiana* (Bio Power® WP) (60gm/20L). The predator we used was *Chrysoperla carnea* (200 larve/kirate)

3. The experimental treatments were as follow

In the research, there were four treatments selected including untreated check (Table 1).

Treat 1

Chemical control: In the chemical treatment, the insecticides were applied with the help of the knapsack sprayer. The first application of insecticides was done after one month of transplanting and subsequent applications were done at 15day intervals.

Treat 2

Mixed control: In the mixed treatment, the first release with *C. carnea* was done by releasing about two hundreds of 2nd instar larvae randomly on 15th October, 2019 and followed by spraying chemical insecticide at 15 day intervals until end of the season.

Treat 3: Biological control: In the biological control, field trials were carried out to determine the efficacy of *C. carnea* and *B.bassiana* in alternative way at 15 day intervals.

Treat 4: Untreated check

4. Percentage reduction of *A. gossypii*

The percent reduction of *A. gossypii* population for each treatment was calculated by the formula (Henderson & TILTON, 1955) as follows:

$$\text{Reduction \%} = \left(1 - \frac{A \times C}{B \times D}\right) \times 100$$

A - Population in a plot after treatment.
B - Population in a plot before treatment.
C - Population in check plot before treatment.
D - Population in check plot after treatment.

5. Average yield

Every two days, fruits were collected from the plants and weighed before being expressed in terms of feddan.

6. Economic analysis

1. Cost of cultivation

Based on local prices for labour, fertiliser, pesticides, and other necessary agro-inputs, the cultivation cost of crops was determined and explained as the total cost of feddan.

2. Gross and net return

Each plot's total fruit output was multiplied by the local market's per-unit fruit price (7000 L.E.), which was then expressed in feddan for all replications and treatments.

3. Insecticide costs/feddan (L.E)

970, 360, 1300 Mix control, Chemical control, Biological control, respectively in the first season and were 1002, 456, 1300 respectively, in the second season

4. Constant service costs L.E 13000/fed.

5. Total costs of control = insecticide price + constant service control/fed

6. Net return /feddan=Gross monetary return/feddan – Total costs of control / feddan.

7. Additional return= treatment return-control return.

8. Profit for one Egyptian pound= Additional return ÷ Total costs of control.

9. Statistical analysis

Statistical significance data was determined with one-way analysis of variance (ANOVA) as randomized complete blocks design (RCBD) and the comparisons among the means of different treatments were carried out using the revised L.S.D test as described by (Duncan, 1955) [5].

Results and discussion

Effect of treatmets against *A. gossypii* on the leaves of squash plants.

Recently, aphid has been spread rapidly throughout the infestation of leaves of growing plants in most of squash plantations in Egypt. Ultimately, a variety of pest management tactics will have to be employed to manage *A. gossypii*, including mix, chemical and biological control. The efficiency of these treatments was evaluated on the leaves of infested plants. These leaves were checked before and after the application of the tested treatments.

1. Efficacy of treatment during nili cultivation of season 2019 and season 2020 against *A. gossypii*

From the above cited results (Tables 4 & 5) general mean of reduction percentages of *A. gossypii*, caused by chemical control, mix control and biological control, were 87.25, 74 and 73.25, respectively (season 2019) and 58.5, 53.75 and 14.5, respectively (season 2020). It could be concluded that the superior efficient toxic effect of tested treatment was revealed for chemical during season 2019 and season 2020 followed by the 2*nd* ranked mix compared to that calculated general mean of reduction by bio.(S Abbas *et al*., 2020) found that high mortality of aphid was recorded in chemical control followed by biological control. (Ali *et al*, 2005) Buprofezin is highly specific against homopteran pest such as whiteflies (*B. tabaci*) and others (Majeed *et al*., 2017) [15] and (Ambethgar, 2018) [3] *B. bassiana*, is appearing to be effective, environment-friendly and target-specific biological control tools against many sucking insect pest species. According to (Kim *et al*., 2007) [12], it has been demonstrated that the entomopathogenic fungus *B. bassiana* increases aphid mortality in potato and glasshouse aphid (*Aulacorthum solani*). According to (Shrestha, *et al*., 2013) [16], Lacewing species have demonstrated the greatest potential as aphid predators. Although both investigations were carried out on a modest scale, lacewing larvae were found to lower aphid populations in studies utilising the shallot aphid (*Myzus ascalonicus*) and currant-lettuce aphid (*Nasonovia ribisnigri*). According to (Saleh *et al*., 2017) [19] *C. carnea* is a significant predator of several white flies, aphids, and thrips. In semi-field circumstances on cantaloupe,

2. Effect of different treatments on the yield of squash plants season of 2019&2020

The estimated yield of squash crop post application of the treatments was significant by higher (4.848 & 4.572 ton/fed.) for chemical, followed by mix control (4.1064 & 4.020 ton/fed.) followed by bio control (2.9256 & 3.8748 ton/fed.) Compared to (2.6172 & 2.7468 ton/fed.) for the untreated control for season of 2019&2020 respectively (Table 4 & 5) (Parajuli, *et al.*, 2020) [16] They discovered that chemical control was superior in terms of yield and the decrease of insect pests According to (Mahato, 2017) [13], the plots with the effective insecticides for controlling the main cucumber pests produced the maximum yield.

3. Economics and profits of the tested treatments to control *A. gossypii* in season 2019

This area of research focuses on using chemical, biological, and mix controls as techniques for managing *A. gossypii* in order to push up yields and boost profits on the cash crop. The yields of the applied treatments for local marketing came to 4.848, 4.1062, 2.9256, and 2.6172 tons/fed, respectively, for the chemical control, mix control, biological control, and untreated check**.**

The gross monetary gain for the Egyptian complete sale was calculated to be 7000 L.E. The returns for chemical control, mix control, biological control, and untreated check were L.E/fed 33936, 28743.4, 20479.2, and 18320.4 respectively. Instead of the yields achieved in the check, the chemical control and mix control offered higher yields, followed by the biological control (Table,4)

Regarding the overall costs of control (variable costs + constant service costs), these constant service costs were reflected in the various agricultural strategies used during the growing season. For chemical control, mix control, biological control, and untreated check these expenditures were L.E 13360, 13970, 14300, and 13000 L.E/fed respectively**.**

Regarding the net returns, the values were 20576, 14773.4, 6179.2 and 5320.4 L.E/fed for chemical control, mix control, biological control and untreated check, successively.

Additionally, for the additional return over the untreated control, the corresponding numbers for the chemical control, mix control, biological control, and untreated check, in that order, were 15255.6, 9453, 858.8, and 0.00**.**

Chemical control, mix control, and biological control yielded returns were 1.14, 0.68, 0.060, and 0.00 for every Egyptian pound (L.E) invested.

4. Economics and profits of the tested treatments to control *A. gossypii* in season 2020

The yields of the treatments used for local marketing were 4.572 tons/fed for chemical control, 4.020 tons/fed for mix control, 3.8748 tons/fed for biological control, and 2.7468 tons/fed for untreated check**.**

The gross monetary gain for the Egyptian complete sale was calculated to be 7000 L.E. The returns for chemical control, mix control, biological control, and untreated check were L.E/fed 32004, 28140, 27123.6, and 19227.6 in that order. Compared to the yields obtained in the check, the chemical control, mix control, and biological control all produced higher yields (Table, 5).

Regarding the overall costs of control (variable costs + constant service costs), these constant service costs were reflected in the various agricultural strategies used during the growing season. For chemical control, mix control, biological control, and untreated check these expenditures were L.E 13456, 14002, 14300, and 13000 L.E/fed respectively**.**

In terms of net returns, the numbers for chemical control, mix control, biological control, and untreated check, in that order, were 18548, 14138, 12823.6, and 6227.6 L.E/fed**.**

Additionally, for the increased return over the untreated control, the corresponding numbers for the chemical control, mix control, biological control, and untreated check, in that order, were 12320.4, 7910.4, 6596, and 0.00.

For each Egyptian pound (L.E) invested, the earnings for chemical control, mix control, biological control, and untreated check were 0.92, 0.56, 0.46, and 0.00 respectively**.** These economic estimates were made using the calculations of **(**M El-Adawy *et al*., 2017) [14].

Based on the profit data for (2019 & 2020), it is possible to infer that the greater value is thought to be the most profitable course of action. However, the used therapies could be ranked in descending order as follows depending on investment profits. Chemical control is followed by mix control and biological control. These outcomes are in line with 2020 (Parajuli *et al*., 2020.) [16] They discovered that using chemicals to manage the main squash pests yielded the greatest benefits.

Conclusion

Different control programmes (mix control, biological control, and chemical control) were applied for controlling *A. gossypii* on squash plants under field conditions. A high benefit and greatest production were obtained with the use of chemical control; in addition, it was very effective for managing *A. gossypii*.

Table 1: The exact application plan during season 2019 and season 2020

Treatments	Season 2019			Season 2020		
	14/10/2019	28/10/2019	14/11/2019	12/10/2020	27/10/2020	13/11/2020
Chemical	Buprofezin	Buprofezin	Super Alpha	Buprofezin	Buprofezin	Super Alpha
Mix	*C. carnea*	Buproezin	*B. bassiana*	*B. bassiana*	Buprofezin	*C. carnea*
Bio	*C. carnea*	*B. bassiana*	*B. bassiana*	*B. bassiana*	*C. carnea*	*B. bassiana*

Table 2: Efficiency of tested treatments on the calculated reduction percentages of infested squash plants by aphid during season of 2019.

Treatment	No. of individuals pre treatment	No. of inspected insects individuals after treatments																General mean of reduction%
		21/10/2019		28/10/2019		4/11/2019		11/11/2019		18/11/2019		1/12/2019		8/12/2019		18/12/2019		
		A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	
Mix	$4.33^{a}\pm0.88$	$0^{a}\pm0.00$	100	$0.33^{b}\pm0.34$	94	$0^{a}\pm0.00$	100	$0^{a}\pm0.00$	100	$4.33^{bc}\pm1.20$	82	$29.66^{b}\pm8.69$	12	$22^{b}\pm4.62$	51	$28.66^{b}\pm6.07$	53	74
Chemical	$9^{a}\pm2.52$	$0^{a}\pm0.00$	100	$0^{b}\pm0.00$	100	$0^{a}\pm0.00$	100	$0^{a}\pm0.00$	100	$2.33^{c}\pm1.33$	95	$17.33^{b}\pm4.06$	75	$43.66^{a}\pm4.38$	53	$32^{b}\pm6.16$	75	87.25
Biological	$7^{a}\pm1.73$	$0.33^{a}\pm0.34$	87	$0^{b}\pm0.00$	100	$0^{a}\pm0.00$	100	$0^{a}\pm0.00$	100	$8.33^{b}\pm1.20$	75	$60.33^{a}\pm0.66$	82	$49^{a}\pm4.94$	32	$88.66^{a}\pm8.96$	10	73.25
Untreated check	$3.66^{a}\pm1.20$	$1.33^{a}\pm0.88$		$5^{a}\pm0.58$		$1^{a}\pm0.82$		$0.33^{a}\pm0.34$		$20.33^{a}\pm2.40$		$28.33^{b}\pm3.18$		$37.66^{a}\pm5.21$		$51.66^{b}\pm9.62$		
$L.S.D_{0.05}$	5.54	1.54		1.09		1.63		0.54		5.27		16.50		15.61		25.61		

A: Mean number of insects± S.E **B:** % Reduction

In each column, means followed by a common letter are significant different at 5% level by ANOVA Randomized Complete Blocks (F. test).

Table 3: Efficiency of tested treatments on the calculated reduction percentages of infested squash plants by aphid during season of 2020

Treatment	No. of individuals pre treatment	No. of inspected insects individuals after treatments																General mean of reduction%
		18/10/2020		25/10/2020		1/11/2020		8/11/2020		15/11/2020		22/11/2020		29/11/2020		6/12/2020		
		A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	
Mix	$15^{a}\pm2.09$	$2.6^{c}\pm0.66$	63	$1^{c}\pm0.58$	86	$2.3^{c}\pm0.34$	57	$13.3^{ab}\pm2.34$	-20	$11.3^{b}\pm2.03$	30	$21.6^{b}\pm2.40$	34	$3.6^{c}\pm0.34$	91	$15.3^{c}\pm1.46$	89	53.75
Chemical	$14.33^{a}\pm1.77$	$7^{ab}\pm1.00$	-3	$1^{c}\pm0.58$	86	$0.3^{c}\pm0.34$	94	$3.6^{c}\pm0.66$	66	$18.3^{ab}\pm3.39$	-18	$10.6^{c}\pm0.66$	66	$4^{c}\pm1.00$	89	$15.3^{c}\pm2.34$	88	58.5
Biological	$16.66^{a}\pm1.46$	$3.6^{bc}\pm0.88$	54	$13^{a}\pm0.58$	-60	$11.15^{a}\pm2.03$	-88	$9.3^{b}\pm0.66$	24	$3.6^{c}\pm0.34$	80	$37.3^{a}\pm2.67$	-3	$15^{b}\pm2.52$	65	$83.3^{b}\pm5.24$	44	14.5
Untreated check	$19.66^{a}\pm3.19$	$9.3^{a}\pm2.03$		$9.6^{b}\pm0.67$		$7^{b}\pm1.53$		$14.5^{a}\pm0.87$		$21.3^{a}\pm2.34$		$42.6^{a}\pm5.37$		$50.6^{a}\pm4.85$		$175.6^{a}\pm12.46$		
$L.S.D_{0.05}$	7.23	4.10		1.96		2.77		5.01		7.49		10.58		9.06		22.46		

A: Mean number of insects± S.E **B:** % Reduction

In each column, means followed by a common letter are significant different at 5% level by ANOVA Randomized Complete Blocks (F. test).

Table 4: Economics and profits of the used treatments compared with the control against *Aphis gossypii* in 2019

Treatments	No. of Treatment applications	Squash yields (metric ton/feddan)	Gross monetary return/feddan (L.E)	Insecticide costs/feddan (L.E)	Constant service costs	Total costs of control /feddan (L.E)	Net returns/feddan (L.E)	Additional return over untreated control (L.E)	Profit one pound investment (L.E)
Mix	3	4.1062	28743.4	970	13000	13970	14773.4	9453	0.68
Chemical	3	4.848	33936	360	13000	13360	20576	15255.6	1.14
Biological	3	2.9256	20479.2	1300	13000	14300	6179.2	858.8	0.060
Untreated check	0.00	2.6172	18320.4	0.00	13000	13000	5320.4	0.00	0.00

Table 5: Economics and profits of the used treatments compared with the control against *Aphis gossypii* in 2020

Treatments	No.of Treatment applications	Squash yields (metric ton/feddan)	Gross monetary return/feddan (L.E)	Insecticide costs/feddan (L.E)	Constant service costs	Total costs of control /feddan (L.E)	Net returns/ Feddan (L.E)	Additional return over untreated control (L.E)	Profit one pound investment (L.E)
Mix	3	4.020	28140	1002	13000	14002	14138	7910.4	0.56
Chemical	3	4.572	32004	456	13000	13456	18548	12320.4	0.92
Biological	3	3.8748	27123.6	1300	13000	14300	12823.6	6596	0.46
Untreated check	0.00	2.7468	192276	0.00	13000	13000	6227.6	0.00	0.00

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