

Appraisalment of various natural methods for controlling some sap-sucking pests on cucumber plant

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Abstract

Two experiments were performed in Qalubiya governorate, Egypt in autumn plantation during two seasons (2022 and 2023). The first experiment was conducted to evaluate the efficacy of three bio insecticides: *Bacillus thuringiensis* (Dipel), Prev-AM (Orange oil), and Buprofezin (IGR) compared to one conventional insecticide; Imidacloprid (Condor 35% SC.) on the population of whitefly; *Bemisia tabaci* (Genn.) (Hemiptera, aleyrodidae) and aphid; *Aphis gossypii* Glover (Hemiptera: Aphididae). The results revealed that Imidacloprid demonstrated the highest overall reduction for both whitefly adults and nymphs (exceeding 88.5% and 94.6% in the first season). Prev-Am (Orange Oil) showed promising results as well, achieving an average reduction of around 80% for both stages. Buprofezin and Dipel had lower average reduction percentages. Similar trends were observed for aphid control. Imidacloprid provided the most significant impact, with an average reduction exceeding 97.5% across both seasons. Prev-Am and Buprofezin showed moderate efficacy, achieving average reduction percentages of around 83.8% and 74.0%, respectively.

The second experiment explored the potential benefits of intercropping cucumber with two aromatic plants: celery (*Apium graveolens* L.) and coriander (*Coriandrum sativum* L.). This strategy aimed to repel insect pests and attract natural enemies of the target pests. Cucumber monoculture (planted alone) harbored the highest number of piercing-sucking pests (whiteflies and aphids) across both seasons. Intercropping with celery significantly reduced whitefly infestation compared to coriander or monoculture. Conversely, intercropping with coriander led to the lowest aphid infestation.

Notably, intercropping with both aromatic plants generally increased the presence of natural predators compared to monoculture.

Keywords: Cucumber, aromatic plant, coriander, celery, intercropping, biorational insecticides, natural enemies, sap-sucking pests, whitefly, aphid, repellent, attract, and chemical insecticides

Introduction

Cucurbits occupy an essential place in the production of vegetables in many countries. In Egypt, cucumber; *Cucumis sativus* L is one of the most important cucurbitaceous vegetable crops. It is grown across a vast region on either old or recently reclaimed ground. Additionally, cucumber is grown in greenhouses and open fields under various climatic circumstances for both local consumption and exports (Hanafy *et al.*, 2008; Mohamed, 2012; Baiomy and Shalaan 2015; Ali *et al.* 2020) [13, 25, 6, 2].

Piercing sucking pests (aphids, whitefly and thrips) have economic importance, they are widely spread attacking a wide variety of vegetable crops and causing serious damage, either directly by sucking plant juice or indirectly as vector transmitting plant viruses and diseases (Hegab, 2009; Ghallab *et al.* 2011; and shalaby *et al.* 2021) [16, 12, 27]. However, cucumber plants are exposed to infestation by sucking pests such as whitefly; *Bemisia tabaci* (Genn.), and aphids; *Myzus persicae* (Sulzer) were economically important pests on cucumber (*Cucumis sativus* L.) in Egypt and different parts of the world (Hanafy *et al.* 2014) [14].

There is a growing concern among ecologists about the harmful effects of pesticides on humans and other living beings such as natural enemies (Dent and Binks, 2020) [9]. Additionally, some pests have developed resistance to frequently used pesticides. As a result, there is an increasing interest in finding non-chemical and ecologically friendly components or techniques to manage pests (Parker *et al.* 2013) [26]. One effective pest management method is the use

of intercropping systems, which involve planting different crop varieties or species within a single field to prevent herbivore outbreaks (Vandermeer 1989; Alttieri 1994 and Altieri and Nicholls 2018) [33, 5]. Diverse plantings provide a wider range of resources for natural enemies such as predators to utilize, including non-pest prey, which helps in building natural enemy communities and strengthening their impact on pests (Parker *et al.* 2013) [26].

Ladybird *Coccinella undecimpunctata* Linnaeus (Coleoptera: Coccinellidae) and aphid lion *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) predators; are known as important biological control agents as natural enemies, that feed on numerous insects such as; whiteflies, all stages of aphids, and neonates of lepidopteran insects (Hodek, van Emden and Honěk, 2012; Baiomy and Shallaan, 2015; El-Ghanam, 2017; Halder and Seni, 2021) [19, 6, 11, 15].

Botanical bio-insecticides derived from azadirachtin, orange oil and jojoba oil as well as insect growth regulators pyriproxyfen, buprofezin and novaluron good compounds and suitable for integrated pest management (IPM) programs of sucking piercing insects (Khalifa and Bedair, 2023) [22].

Non-conventional insecticides; like Dipel, which is prepared from dry flowable formulations containing live spores and endotoxin of naturally occurring bacterium (Bt) *Bacillus thuringiensis* sub sp., and botanicals derived from orange oil, as well as insect growth regulators like and buprofezin, can be used as alternatives to conventional chemical insecticides like imidacloprid.

The intercropping system offers an environmentally friendly approach to reducing pest damage in agro-ecosystems. The effect of intercropping on natural enemies, which is essential for the success of integrated pest management, varies in different intercropping systems (Li *et al.*, 2021) [23].

The aim of this work is: to study the efficiency of four different control agents; two of them are bio components (orange oil and IGR), one agent is bio-pesticide (Dipel), and one chemical pesticide (Imidacloprid) on reducing of *Bemisia tabaci* and *Aphis gossypii* on cucumber plants. Also, to evaluate the intercropping system repellency effect due to odorous ornamental plants against the sap-sucking pests and maintaining the natural enemies on cucumber plants.

Materials and Methods

Field experiments were conducted at Qalubiya Governorate, Egypt, during the fall planting seasons of 2022 and 2023.

Experimental area: The experimental area was 352 m² and divided into 32 plots (11m² each) cultivated with cucumber plants; *Cucumis sativus* L. (variety Sweet crunch). Seeds were directly sown in the open field on September 15th of each season.

Experimental design: A randomized complete block design with four replicates per treatment was employed. All plots received recommended agricultural practices throughout the growing seasons.

Investigated Treatments: The study employed two main approaches to manage whitefly and aphid pests on cucumber plants:

Insecticide application: This approach involved five different treatments. Three of these treatments evaluated the effectiveness of biorational insecticides (orange oil, insect growth regulator (IGR) and *Bacillus thuringiensis* (Bt), while one treatment assessed a standard chemical insecticide (Imidacloprid) as shown in (Table 1). A control plot with cucumber plants receiving no insecticide application was also included. Treatments were applied with the respective insecticides using a (10 Liters) knapsack sprayer with one nozzle.

Data collection: Plant inspections were conducted before spraying and after 1, 3, 5, and 7 days post-application to assess the efficacy of the treatments in reducing pest populations.

Intercropping: Three additional treatments evaluated the effectiveness of intercropping celery and coriander plants with cucumber plants in reducing whitefly and aphid infestation. Single planted of cucumber were used as control.

Table 1: The tested control agents

Trade name	Common name	Recommendation
PREV-AM 6% SL	Orange oil (d-limonene)	500 ml / 100 liter water
Applaud 25% SC	Buprofezin (IGR)	600 cm ³ / fed.
Dipel 6.4% DF	<i>Bacillus thuringiensis</i> subsp. kurstaki (Bt.)	10 gm / 100 liter water
Condor fast 35% SC	Imidacloprid	75 ml / 100 liter water

Sampling methods

Plants were examined in the field as soon as true leaves appeared. Leaf samples were taken for examination in the laboratory two weeks after germination. Weekly samples of five leaves per plot were randomly collected from each plot. Leaves samples were placed in paper bags and transported to the laboratory for inspection, and counting of *Bemisia tabaci* (Genn.) (Nymphs) and *Aphis gossypii* Glov. (Nymphs and Adults). Counts of whitefly adults were done in the early morning before flight activity.

Statistical Analysis

Data collected from the experiment were subjected to statistical analysis to determine the effectiveness of each treatment.

Insecticide efficacy: The percentage of corrected mortality was estimated according to Henderson and Tilton (1955) formula.

$$\text{Mortality} = [1 - (\text{Ta} * \text{Cb}) / (\text{Tb} * \text{Ca})] * 100$$

Where: Ta: post-treatments counts.

Cb: untreated counts before treatments.

Tb: pre-treatments counts.

Ca: untreated counts after treatments.

For testing the homogeneity of the control agent Chisquare analysis " χ^2 " method was used by Snedcor and Cochran (1982).

Intercropping efficiency

The reduction percentages of pest infestation between intercropping treatments were calculated using the following formula according to (Khafagy *et al.* 2020) [20]:

$$\text{Reduction (\%)} = (\text{infestation in control} - \text{infestation in treatment}) / \text{infestation in control} * 100$$

Data analysis software: Data analysis was performed using SPSS Version 23. One way ANOVA was conducted with a significance level of $P < 0.05$.

Results and Discussion:

1. Effect of different control agents on whitefly:

Results in Tables 2 and 3 show the effectiveness of various biorational insecticides on population reduction of whitefly; *Bemisia tabaci* (adult and nymph) during two seasons. Five insecticide; Prev-Am (Orange Oil), Buprofezin (Insect Growth Regulator), Dipel (Bt.) (*Bacillus thuringiensis*) and Condor 35% Sc (Imidacloprid) were applied as a single spray per season.

Table 2: Effect of various biorational insecticides on the percentage of reduction population of the whitefly, *Bemisia tabaci* (Genn.) on Cucumber plants 1st season 2022.

Reatments	Adults stage						Nymphs stage					
	Pre-treat	Post-treatment reduction% observation					Pre-treat	Post-treatment reduction% observation				
		Initial effect	Residual effect			Mean reductions		Initial effect	Residual effect			Mean reductions
	24hours	3Days	5Days	7Days			24hours	3Days	5Days	7Days		
Prev-Am (Orange Oil)	46	77.90	86.08	76.90	70.50	77.8 b	54	78.4	86.8	89.5	79.9	83.7 b
Buprofezin (IGR)	36.5	35.66	48.68	66.24	60.58	52.8 c	57	58.6	72.2	86.6	89.1	76.6 b
Dipel (Bt)	61	31.56	53.02	67.73	61.60	53.5 c	60	50	76.4	80.4	78.8	71.3 c
Condor 35%Sc (Imidacloprid)	52	93.44	91.95	88.22	80.33	88.5 a	67	97.9	96.7	93.9	89.7	94.6 a
Control	81.	-----	-----	-----	-----	-----	50	-----	-----	-----	-----	-----
Chi-square test statistic (X ²) CX ² =44.11 sig. at 0.05 a, b, c means there is a significant difference						X ² =20.24 sig. at 0.05 a, b, c means there is a significant difference						

Table 3: Effect of various biorational insecticides on the percentage of reduction population of the whitefly, *Bemisia tabaci* (Genn.) on Cucumber plants 2nd season 2023.

Treatments	Adults stage						Nymphs stage					
	Pre-treat	Post-treatment reduction% observation					Pre-treat	Post-treatment reduction% observation				
		Initial effect	Residual effect			Mean R%		Initial effect	Residual effect			Mean R%
	24hours	3Days	5Days	7Days			24hours	3Days	5Days	7Days		
Prev-Am (Orange Oil)	17	80.6	87.4	82.8	75.7	81.6 b	87	81.2	87.8	88.1	82.9	85.0 b
Buprofezin (IGR)	14	48.8	52.8	74.1	70.1	61.5 c	69	55.0	73.9	82.6	83.4	74.0 b
Dipel (Bt)	20	53.5	61.2	76.4	69.9	65.3 c	93	48.9	70.3	78.5	76.7	68.6 c
Condor 35%Sc (Imidacloprid)	24	94.4	92.3	90.3	88.6	91.4 a	100	97.0	94.9	93.58	90.1	93.9 a
Control	75	-----	-----	-----	-----	-----	98	-----	-----	-----	-----	-----
Chi-square test statistic (X ²) X ² =31.36 sig. at 0.05 a, b, c means there is a significant difference						X ² =24.31 sig. at 0.05 a, b, c means there is a significant difference						

Pre-treatment and post-treatment counts were recorded for whitefly; stages adult and nymphs at 24 hours, 3 days, 5 days, and 7 days. Condor 35%Sc (Imidacloprid) achieved the highest overall population reduction for both adults and nymphs, with an average reduction 88.5% and 94.6%, respectively, in the 1stseason. Prev-Am (Orange Oil) showed promising results, achieving an average reduction 77.8% for adults and 83.7% for nymphs. Buprofezin and Dipel had lower average reduction percentages compared to the other treatments, ranging from 58.6% to 76.4% across all observation periods (24 hours, 3 days, 5 days, and 7 days). The general reduction percentage cleared that there were significant differences between Imidacloprid and all other treatments on both studied whitefly stages (adults and nymphs). While, the difference between the reduction percentages of Buprofezin (IGR) and Dipel (Bt.) on both of adults (52.8% and 53.5%) and nymphs (76.6% and 71.3%) were insignificant. Also, there was no significant difference between the reduction percentages of Orange oil and Buprofezin (IGR) on whitefly nymphs (83.7% and 76.6%). Regarding the 2ndseason data had the similar trends like 1stseason, Imidacloprid remains the most effective insecticide, achieving an overall average reduction exceeding 91% for both adults and nymphs. Also, Prev-Am (Orange Oil) shows moderate effectiveness with an average reduction of around 81% for adults and 85% for nymphs. Lower efficacy for Buprofezin and Dipel: Similar to the 1st season, Buprofezin and Dipel continued to have lower average reduction percentages, ranging from 61% to 68%. These results are contrast with Bi *et al.* (2002) [8], who said that Buprofezin was effective in controlling the immature stages of whitefly on strawberry plants in the greenhouse and significantly reduced adults of whitefly on strawberry plants in the field. Buprofezin was highly effective against

whitefly in okra plants, (Bhatt *et al.* 2018) [7]. imidacloprid achieved good reduction percentages against whitefly nymph after 48 hr. of application El-Bessomy (2003) [10]. Khalifa (2021) [21] and Khalifa and Bedair (2023) [22] also mentioned that Imidacloprid showed the highest initial effect on the population of whitefly (adults and nymphs) in cucumber. Ali *et al.* (2023) [3] indicated that, Sulfoxaflor followed by Buprofezin, were effective against both adults and nymphs of *B. tabaci* after one day for two sprays. While Buprofezin was more effective than Sulfoxaflor against nymphs of *B. tabaci*.

2. Effect of different control agents on aphids:

The data in Tables 4 and 5 show the percentage reduction of aphids during the 2022 and 2023 seasons at 1, 3, 5, and 7 days, as well as the overall reduction percentage under the tested treatments. Imidacloprid demonstrates superior efficacy in decreasing the aphid population, achieving reduction percentages of 97.48% and 96.45% in the first and second seasons, respectively. The differences between Imidacloprid and the other three treatments Orange oil, Buprofezin (IGR), and Dipel (Bt.) were significant in each season. While, there were no significant differences between the reduction percentages of Orange oil and Buprofezin (IGR) on aphid population (85.0% and 74.5%) in the 1st season and (82.5% and 73.6%) in the 2nd season, respectively. In general, Imidacloprid was the most effective insecticide against aphids, followed by Orange Oil, with Buprofezin and Dipel showing lower efficacy. Abdel-Rahman and Abou-Taleb (2008) [1] conveyed that Imidacloprid was the most effective against aphids on cotton plants. Shehata *et al.* (2009) [31] and Khalifa and Bedair (2023) [22] also mentioned that the highest aphids control was accomplished by imidacloprid on cucumber.

Table 4: Efficacy of various biorational insecticides on the percentage of reduction population of the Aphid, *Aphis gossypii* Glov. on Cucumber plants 1st season 2022.

Treatments	Pre-treat	Post-treatment reduction% observation					Mean reductions
		Initial effect	Residual effect				
		24hours	3Days	5Days	7Days		
Prev-Am (Orange Oil)	168	83.4	86.7	86.24	83.4	85.00 b	
Buprofezin (IGR)	189	53.55	78.2	83.26	82.5	74.39 b	
Dipel (Bt)	114	51.1	78.3	79.9	71	70.08 c	
Condor 35%Sc (Imidacloprid)	123	99.03	98.00	97.1	95.8	97.48 a	
control	160	-----	-----	-----	-----	-----	

Chi-square test statistic (X²) X²=30.04 sig. at 0.05
a, b, c means there is a significant difference

Table 5: Efficacy of various biorational insecticides on the percentage of reduction population of the Aphid, *Aphis gossypii* Glov. on Cucumber plants 2nd season2023.

Treatments	Pre-treatment	Post-treatment reduction% observation					Mean reductions
		Initial effect	Residual effect				
		24hours	3Days	5Days	7Days		
Prev-Am (Orange Oil)	252	80.1	83.2	84.5	82.3	82.53 b	
Buprofezin (IGR)	241	55	76.8	80.8	81.8	73.60 b	
Dipel (Bt)	236	50.1	69.7	73.2	75.5	67.13 c	
Condor 35%Sc (Imidacloprid)	253	97.8	98.5	96.5	93.8	96.45 a	
control	206	-----	-----	-----	-----	-----	

Chi-square test statistic (X²) X²=30.24 sig. at 0.05
a, b, c means there is a significant difference

3. Effect of intercropping system

Population density of certain sucking pests and their associated predators in cucumber fields

During the study period, the most common insect pests that infested cucumber plants were aphid (*Aphis gossypii*) and whitefly (*Bemisi atabaci*), along with a few cotton thrips *Thrips tabaci*. The primary predators that observed were *Coccinella undecimpunctata* L. (Coleoptera, Coccinellidae) and *Chrysoperla carnea* Steph. (Neuroptera, Chrysopidae). On leaves of celery plant, a reasonable number *C. carnea* eggs were found, while on coriander plant leaves, no predator eggs were observed.

Data in Table 6 indicates that cucumber plants hosted the highest number of piercing-sucking pests (1152 and 1219) compare to cucumber plants intercropped with either celery (265 and 303) or coriander (403 and 476) during the autumn plantation of two study seasons 2022 - 2023. On the other hand; cucumber plants intercropped with celery had a lower infestation of whiteflies represented by 42.64% in the first season and 42.25% in the second season compared to those intercropped with coriander 75.68% for the first season and 78.74% for the second season, respectively. On the other hand, aphid infestation was higher on cucumber plants intercropped with celery plants (55.47% and 55.44) as compared to those intercropped with coriander (23.33% and 20.56%) during the first and second seasons, respectively.

Table 6: Total numbers of sap-sucking pests and their associated predators on cucumber plants during autumn plantation in two successive seasons (2022-2023).

Seasons Insects	First season						Second season					
	Cucumber+ Celery		Cucumber + Coriander		Cucumber		Cucumber+ Celery		Cucumber + Coriander		Cucumber	
	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
<u>Insect pests</u> Aphids	147	55.47	44	10.9	355	30.82	171	55.44	78	16.39	415	34.04
Whitefly	113	42.64	355	88.1	687	68.23	125	42.25	393	82.56	795	65.22
Thrips	5	1.89	4	1.0	11	0.95	7	2.31	5	1.05	9	0.74
Total	265	100	403	100	1053	100	303	100	476	100	1219	100
<u>Insect predators</u> <i>Coccinella undecimpunctata</i>	26	43.33	37	58.73	26	54.17	19	34.55	30	52.63	21	52.5
<i>Chrysoperla carnea</i>	34	56.67	26	41.27	22	45.83	36	65.45	27	47.37	19	47.5
Total	60	100	63	100	48	100	55	100	57	100	40	100

During the study period, it was observed that the population of *C. carnea* predators was higher on cucumber intercropped with celery (34 and 36) compared to cucumber with coriander (26 and 27) or cucumber alone (22 and 19) for the first and second season, respectively. Overall, the total number of predators recorded on cucumber plants planted alone during the two seasons was the lowest compared to those recorded on cucumber plants intercropped with celery and coriander plants. The effect of intercropping on natural enemies, which is essential for the success of integrated pest management, varies in different intercropping systems (Li *et al.*, 2021) [23].

Effect of intercropping between cucumber plants and some aromatic plants on the population number of two tested insects

Data presented in Table (7) show the effect of intercropping between cucumber plants and some aromatic plants on the number of whitefly; *Bemisia tabaci* and aphids; *Aphis gossypii* during the autumn plantation of 1st season 2022. Regarding the adults of whitefly; the highest average numbers of adults were recorded in the third week of November 2020 on cucumber alone followed by cucumber with Coriander and celery and represented by 41, 30, and 6

adults \ leaf, respectively. It can be noticed that the highest seasonal average number of adults recorded on cucumber alone (20.8), followed by cucumber with Coriander (13.4), and celery came in the last ranking (1.2 adults). Statistical analysis revealed that highly significant differences were

found between cucumber with celery and cucumber alone that figured to a high capability of celery to repellent whitefly adults compared to cucumber with coriander or with cucumber alone.

Table 7: Effect of intercropping pattern on the average number of sap-sucking pests during autumn plantation in the 1st season 2022.

Cucumber intercropping pattern										
Sampling Date		Cucumber with celery			Cucumber with Coriander			Cucumber alone		
		Whitefly		aphid	Whitefly		aphid	Whitefly		aphid
		A	N		A	N		A	N	
Oct.	1	0	0	0	1	8	0	5	10	1
	2	0	2	2	7	12	0	12	19	1
Nov.	1	2	1	5	12	12	1	25	23	3
	2	0	1	2	19	17	3	28	31	15
	3	6	5	16	30	25	5	41	37	38
	4	3	14	35	24	16	3	32	36	50
Dece.	1	0	10	12	16	13	9	14	42	56
	2	0	15	8	9	15	10	21	46	40
	3	1	12	11	9	17	6	27	38	32
	4	0	13	15	4	20	0	10	49	27
Jan.	1	1	7	21	2	10	0	15	48	37
Total		14	99	147	161	194	44	249	438	355
Mean±se		1.2 c±0.5	8.3 c±1.9	12.3 b±2.9	13.4 b ±2.8	16.2 b±1.8	3.7 c ±1.1	20.8a ±2.8	36.5a ±3.9	29.6 a±5.9
% Reduction		94.1a	77.4a	58.6b	32.6b	55.7b	87.6a	-----	-----	-----

Data in Table 8 shows the impact of intercropping cucumber plants with some aromatic plants on the number of whitefly (*Bemisia tabaci*) and aphids (*Aphis gossypii*) during the 2nd

season of 2023. It was observed that cucumber plants intercropped with celery plants had lower

Table 8: Effect of intercropping pattern on the average number of sap-sucking pests during autumn plantation in the 2ndseason 2023.

Cucumber intercropping pattern										
Sampling Date		Cucumber with celery			Cucumber with coriander			Cucumber alone		
		Whitefly		aphid	Whitefly		aphid	Whitefly		aphid
		A	N		A	N		A	N	
Oct.	1	1	1	2	2	3	2	11	17	3
	2	1	1	4	6	8	3	19	30	5
Nov.	1	2	1	5	11	19	4	31	35	11
	2	1	2	14	18	24	8	35	56	25
	3	1	15	17	23	28	17	41	50	42
	4	7	20	24	27	22	14	37	44	61
Dece.	1	2	23	31	29	30	8	23	61	68
	2	1	16	29	17	26	5	18	49	59
	3	3	12	20	15	18	9	28	42	44
	4	1	8	17	14	19	4	33	34	38
Jan.	1	1	3	6	9	11	4	20	33	29
Total		22	103	171	178	215	78	319	476	415
Mean±se		1.8 ±0.5c	8.6 ± 2.4 c	14.3 ±3.1b	14.83 ±2.5 b	17.92 ±2.6 b	6.5 ±1.4 c	26.58 ±2.6 a	39.67 ±3.8 a	34.58 ±6.2 a
%Reduction		93.1a	78.4a	58.8a	44.2b	54.8b	81.2b	-----	-----	-----

Whitefly population (adults and nymphs) compared to those intercropped with coriander plants or not intercropped at all and the difference was significant. Furthermore, cucumber plants intercropped with coriander had the lowest infestation with aphids (6.5 individuals) whereas the mean of aphid population numbers on cucumber with celery and cucumber alone were 14.3 and 34.58 individuals, respectively and the differences were significant.

Our results could be supported by Hilje and Stansly (2008) [18] and Togni *et al.* (2010) [32] found coriander plants have been successfully intercropped with tomatoes to manage whiteflies by reducing the number of incoming adults. Sfara

et al. (2009) [28] and Mann *et al.* (2010) [24], noted that Linalool and α-pinene are major volatiles found in coriander, have been reported to repel several herbivore insects including Hemipterians and might be a reason for decreasing population of insects in plots where coriander is used as intercrop. Tongi *et al.* (2010), said that coriander constitutive volatiles intervene in the host plant selection of whitefly. Also, he illustrated that intercropping tomato with coriander reduces the damage caused by whitefly. Zhao *et al.* (2014) [33] demonstrated intercropping celery and Malabar spinach with cucumber significantly reduced whitefly numbers in cucumber.

Sharma *et al.* (2018) ^[29] found that intercropped okra with coriander was effective in inhibiting the population of whitefly. The intercropping of aromatic plants offers an environmentally friendly approach to reducing pest damage in agro-ecosystem (Li *et al.*, 2021) ^[23].

Conclusion

This study showed that planting cucumber with celery or coriander can significantly reduce the population of sap-sucking pests during autumn cucumber planting. The study suggests that intercropping main crops with aromatic plants can be a valuable and safe addition to integrated pest management programs.

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