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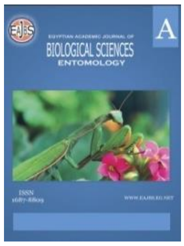

Susceptibility of Three Cucumber Varieties to Whitefly, *Bemisia tabaci* Infestation and Impact of Intercropping of Aromatic Plant Against *Bemisia tabaci* Under Greenhouse

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ABSTRACT

Alternative control techniques are increasingly preferred in the management of vegetable pests because of the detrimental effects of pesticides on the environment and human health. Two popular environmentally friendly control strategies include natural enemy release and intercropping. In this study, the impact of intercropping aromatic plants (sweet pepper, sweet fennel, and marjoram) with three cucumber varieties (Hule, Muluki, and Basha) on the population density of Whitefly and *Bemisia tabaci* compared with non-intercropped plants was indicated during two consecutive seasons (2021 and 2022) under greenhouse conditions. The results showed that planting marjoram significantly reduced the population density of *B. tabaci*, followed by sweet pepper and sweet fennel. Our findings demonstrate the possibility of optimizing sustainable pest management through the integration of alternative pest control technologies.

INTRODUCTION

The cucumber (*Cucumis sativus* L. Fam. Cucurbitaceae) is one of the most important vegetable crops grown in the world. It holds a prominent place among Egypt's vegetable crops (Abdelatef *et al.*, 2022). The plants of cucumber are infected with many pests, including Whitefly, *Bemisia tabaci* (Genn.) (Hemiptera: Aleyrodidae), is an economically important pest on cucumber in different parts of the world as nymphs and adults which sap-suck the juice of the plant, that leads to yellowing of the plant and other indirect damage through the transmission of several viral diseases, including wrinkling and yellowing of the plant and the process of photosynthesis in plants (Ronald *et al.* 2007; Okonmah, 2011). Due to the harmful effects of synthetic pesticides on the environment and human health, in addition to reduced efficacy due to resistance within pest populations, alternative control methods and an increasing interest in natural pesticides, which are assumed to be safer than synthetic pesticides, have become more favored in the framework of integrated pest management (Brewer & Goodell, 2011; Yanar *et al.*, 2011; Khursheed *et al.* 2022). Insects use plant volatiles to locate and recognize potential plant hosts for feeding and oviposition (Kuhnle & Muller, 2011; Wynde & Port, 2012). Accordingly,

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some non-host plants (e.g., aromatic plants) emit volatiles with repellent or deterrent properties as a defense against attack (War *et al.*, 2012) and could be used to develop insect repellents, antifeedants, or insecticides (Bakkali *et al.* 2008; Dalavayi *et al*. 2021). The intercropping of aromatic plants provides an environmentally benign route to reducing pest damage in agroecosystems, and the effect of intercropping on natural enemies, another element that may be vital to the success of an integrated pest management approach, varies in different intercropping systems (Li *et al*., 2021). Plant extracts and botanical pesticides have become increasingly important in agricultural fields in recent years since they are very poisonous against key pests including whiteflies and they are inexpensive, environmentally friendly, and have no residual effects (Daraban *et al.*, 2023). This study aimed to estimate the susceptibility of three cucumber varieties to whitefly, *B. tabaci* infestation and the impact of intercropping aromatic plants with commonly cultivated cucumbers against *B. tabaci* under greenhouse conditions.

MATERIALS AND METHODS

Greenhouse Experiments:

Experiments were carried out in the greenhouse experimental area at Dokki, Giza Governorate, over the course of two consecutive seasons (2021 and 2022) to examine the *Bemisia tabaci* infestation rate on three different varieties of cucumbers: Hule, Muluki, and Basha. Throughout the trial region, conventional farming methods were used without any pesticides. The experimental area of cucumber varieties was 9x40m², and divided into three sectors, in which the three cucumber varieties (Hule, Muluki and Basha) were planted in individual panels. the varieties sowing on the 20th of September, with three replications. In both seasons, samples of 25 leaves per plot were randomly selected every seven days, starting on the 8th of October and ending the last week of December. Every sample was transported to the lab the same day for examination, and it was stored in a securely closed paper bag. Leaves were examined within 24 hours of collection under a stereomicroscope. We counted the nymphs to estimate the infestation of *B. tabaci*.

This experiment was conducted in the 2022 season, where the plants were planted on September 20th and starting on the 8th of October and ending the last week. Samples of 25 leaves per plot were randomly selected every seven days in December. The tested area was divided into three parts, in the first part, the seedlings of the tested aromatic plant (fennel, pepper, and marjoram) were planted on each side of the rows, while the second part was for growing cucumber seedlings without aromatic plants and the third part was for control. The distance between one plant and another is 30cm.

Control Agents:

The effectiveness of three tested aromatic plants and one recommended pesticide against *B. tabaci* were examined in the current investigation. Table 1 shows the trade and the common names of the compounds under study.

Table 1. Insecticides and aromatic plants with their trade name, active ingredient and rate of application.

Trade Name	Common Name
Acetamiprid	**Intercore20%sp (25gm/100L)**
Origanum majorana	**Marjoram plant**
Capsicum annuum	**Sweet pepper plant**
Foeniculum vulgare	**Sweet fennel plant**

Statistical Analysis:

The ANOVA analysis was performed by using the SAS program (SAS Statistical Software, 2000) and the differences between the mean were conducted by the Duncan Multiple Range Test (DMRT) at $p \leq 0.05$.

RESULTS AND DISCUSSION

This study aimed to estimate the susceptibility of three cucumber varieties to whitefly, *Bemisia tabaci* infestation during two successive seasons (2021 and 2022) and the impact of intercropping aromatic plants with commonly cultivated cucumber against *Bemisia tabaci* under greenhouse conditions in Giza governorate.

1-Susceptibility of Three Cucumber Varieties to Whitefly, *Bemisia tabaci* Infestation:

The data indicated that in Table (2), the infection levels of *B. tabaci* were compared for the tested varieties. The results recorded a non-significant relationship in the first season of 2021 between the tested varieties with mean (167.1, 161and151.7) for (Hule, Basha, and Muluki), respectively. While a significant relationship was shown in the second season of 2022 where the F value was 3.06* and the L.S.D. =30.59 with a mean (141.75, 119.6 and 105.6) for (Basha, Hule, and Muluki), respectively. It is clear from the averages that the most affected type was Basha variety, which recorded three peaks in two seasons 2021&2022. The peaks occur in the first season22nd of Oct., 26th of Nov. and 17th of Dec. were registered 213, 279 and 289 nymph/ 25 leaves, respectively. in the second season, the data revealed that the presence of three peaks on the 15th of Oct., 19th of Nov. and 3rd of Dec. were 236, 187 and 201 nymph/ 25 leaves, respectively. The following Variety was Hule which recorded four peaks in season 2021 the peaks occurred on the 22nd of Oct., 5th of Nov., 19th of Nov. and 3rd of Dec. were registered 152, 281, 231 and 210 nymph/ 25 leaves, respectively. On the other, in the second season, the data revealed that the presence of three peaks on the 22nd of Oct., 19th of Nov. and 3rd of Dec. were 105, 189 and 190 nymph/ 25 leaves, respectively. The variety Muluki was less affected by *B. tabaci* Nymph as it recorded four peaks in season 2021 the peaks occurred on the 22nd of Oct., 5th of Nov., 3rd of Dec. and 17th of Dec. were registered 198, 214, 288 and 166 nymph/ 25 leaves, respectively. On the other, in the second season, the data revealed that the presence of three peaks on the 5th of Nov., 26th of Nov. and 17th of Dec. was 165, 161 and 113 nymph/ 25 leaves, respectively. The data show that all varieties had somewhat greater mean numbers of *B. tabaci* stages in 2021 than in 2022 and that the Basha variety was more prone to *B. tabaci* infection. These findings are consistent with prior results (Abd El-Gawad 2008), which demonstrated that the *B. tabaci* infestation during the 2005–2006 Nile season varied significantly depending on the planting date. According to these studies, Ali (1993)., El-Khayat *et al.* (1994), Zaki *et al.* (2002)., and Esmail (2013) found that *B. tabaci* infestations started in fall cucumbers in September, grew to a high population in October and November, and then started to drop as the cucumber growing season came to a close. Additionally, previous studies by Seham *et al.* 1997; Emam *et al*. 2006; and Shaalan, 2016 came to the conclusion that, like in the current study, the various planting dates throughout the year had an impact on the establishment of a variety of pests, including *B. tabaci*. According to El-Lakwah *et al*. 2011 & Ahmed and Hermize 2023 the population density of *B. tabaci* on cucumber plants is larger in the fall than it is in the spring.

Table 2: Susceptibility of three cucumber varieties to whitefly, *Bemisia tabaci* infestation under the greenhouse.

Inspection time	2021			2022		
	Hule	**Muluki**	**Basha**	**Hule**	**Muluki**	**Basha**
08/10	97	77	108	62	43	101
15/10	136	105	181	84	67	236
22/10	152	198	213	105	89	169
29/10	109	122	9	102	103	109
05/11	281	214	6	96	165	96
12/11	149	97	113	133	97	82
19/11	231	135	201	189	103	187
26/11	163	187	279	141	161	153
03/12	210	288	231	190	132	201
10/12	198	143	190	152	105	144
17/12	147	166	289	103	113	126
24/12	132	88	112	78	89	97
Total	2005	1820	1932	1435	1267	1701
Mean	167.1	151.7	161	119.6 AB	105.6 B	141.75 A
F- value	0.19 insign.			3.06*		
L.S.D at 0.05	_______			30.59		

A, AB & B: There is a significant difference (P≤0.05) between any three means.

2-Effect of Intercropping of Aromatic Plant with Commonly Cultivated Cucumber Against *Bemisia tabaci* Under Greenhouse Conditions:

The effect of using aromatic plants (fennel, pepper, and marjoram) to reduce the population density of *Bemisia tabac*i on the Basha variety, in addition to a comparison with using recommended pesticide (Intercore 20%SP) and without any control during the 2022 season under greenhouse conditions.

Data presented in Table (3), indicated, the difference between the effects of using aromatic plants (fennel, pepper, and marjoram) to reduce the population density of *Bemisia tabac*i on the Basha variety. Statistical analysis revealed that the population densities were affected by using aromatic plants. The lowest infestation rate was, generally observed under the use of aromatic plants (fennel, pepper) compared with using pesticides which received the least number of pests 7.25, 8.08, 13.08 and 11.25 individuals compared with using pesticides means 6.33 and 11.67, respectively for two seasons. Using the marjoram plants indicated the highest number of pests 12.67 and 20.08 of individuals for two seasons. Statistical analysis revealed significant differences between the three intercropping of aromatic plants, with F value = 25.13 and L.S.D. = 1.61 individual for the first season 2021 and the second season 2022, whereas F value = 20.81 and L.S.D. = 2.59 individual. The population density of *B. tabaci* was dramatically reduced by intercropping with aromatic plants, which is in line with a prior field investigation by Ben Issa *et al.* (2017). The repellent chemical hypothesis, which states that non-host plant volatiles disrupt host location and feeding by herbivores, could explain why pest densities in the intercropped treatment were lower than in those in the sole crop (Uvah, 1983). Interaction between non-host plants and host plants might result in different behavioral responses in pests for different systems (Zhang and Schlyter 2003). In addition, a variety of parameters, including cultivars, growth stages, and seasons, might influence the semiochemical release from intercrop plants (Sadeh *et al.*, 2019; Zhang *et al.*, 2013). The results of a study assessing the three aromatic plants and systemic insecticides had significantly different effects on the population density of *B. tabaci*. Throughout the trial, the findings corresponded with those of the following studies: Shalaby (2004), Ahmed *et al.* (2014), Qamar *et al.* (2016), Akram *et al.* (2010), Abbassey *et al.* (2009), Vimala *et al.* (1999), and Ismail (2020).

Table 3: Effect of intercropping of aromatic plant with commonly cultivated cucumber against *Bemisia tabaci* under greenhouse conditions.

	2021					2022				
Inspection Time	Fennel	Pepper	Marjoram	Pesticide	Without any control	Fennel	Pepper	Marjoram	Pesticide	Without any control
08/10	10	13	12	11	14	31	27	32	39	41
15/10	23	27	33	31	36	42	39	46	45	56
22/10	7	11	10	3	66	11	10	19	6	95
29/10	8	8	12	5	90	14	14	23	10	109
05/11	10	11	15	9	70	18	16	27	14	132
12/11	15	12	19	10	78	17	12	28	15	111
19/11	5	3	9	0	117	8	6	14	3	129
26/11	1	1	7	0	210	3	2	15	0	163
03/12	3	5	10	2	198	7	4	16	4	182
10/12	5	6	11	5	158	6	5	15	4	198
17/12	0	0	5	0	140	0	0	6	0	147
24/12	0	0	9	0	83	0	0	0	0	91
Total	87	97	152	76	1260	157	135	241	140	1454
Mean	7.25D	8.08 CD	12.67 B	6.33 C	105.0A	13.08 D	11.25 D	20.08 C	11.67 B	121.167A
F value	25.13***					20.81***				
L.S.D. at 0.05	1.61					2.59				

A, B, CD & C, D: There is a significant difference (P≤0.05) between any three means.

CONCLUSION

This research demonstrated that during both seasons, the peak incidence of whiteflies occurred in the months of October and November. This will help establish whitefly management programs in this country. The results of using aromatic plant loading showed a significant result and it is considered a safe and clean method better than using pesticides.

Declarations:

Ethical Approval: Not applicable.

Competing interests: The authors have no competing interests to declare that are relevant to the content of this article.

Contributions: I hereby verify that all authors mentioned on the title page have made substantial contributions to the conception and design of the study, have thoroughly reviewed the manuscript, confirm the accuracy and authenticity of the data and its interpretation, and consent to its submission.

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