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Interaction effect of cantaloupe cultivars and sowing date on *Bemisia tabaci* (Hemiptera: Aleyrodidae) infestation and yield parameters

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Abstract:

Field trials were conducted to study the interaction effect of three cantaloupe sowing dates (Mar. 16; Apr. and Apr.15) and four cantaloupe cultivars (Arava, Majus, Darvina and Royal 481) on *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) over 2015, 2016 and 2017 summer plantation seasons. The obtained results revealed that *B. tabaci* eggs and nymphs were significantly affected by the tested variables (sowing dates and cantaloupe cultivars). In other words, Darvina and Royal 481 were the most oviposited cultivars in the three tested sowing dates, 10.2 and 11.7, 6.3 and 6.7 and 7.56 and 8.9 eggs /leaf, over 2015, 2016, and 2017 seasons, respectively, versus Arava and Majus ,5.6 and 4.5 3.5 and 2.8 and 3.91 and 3.02 eggs/leaf, respectively. Moreover, Darvina and Royal 481 harbored high nymphal infestations 16.92 and 16.4, 14.9 and 13.23 and 13.4 and 11.4 nymphs/leaf verses 11.45 and 9.33, 8.5 and 8.03 and 6.2 and 5.64 nymphs/leaf in Arava and Majus, respectively. The third sowing date Apr.16 harbored the lowest numbers of *B. tabaci* eggs and nymphs/leaf (5.43 and 10.7), (2.77 and 7.1), and (2.4 and 5.94) over the three tested seasons, respectively. On the other hand, the second sowing date; Apr.2 harbored the highest numbers of eggs and nymphs except in 2017 it harbored a moderate number of eggs, and *B. tabaci* eggs and nymphs over 2015,2016 and 2017 were 10.81 and 16.72, 7.21 and 15.3 and 6.21 and 11.85 eggs and nymphs /leaf, respectively. The first sowing date (Mar.16) harbored moderate infestation over the three tested years except in 2017 it was the most deposited and 7.72 and 13.15, 4.5 and 11.1, 8.9 and 9.7 eggs and nymphs /leaf, respectively were recorded over the three seasons, respectively. The lowest infested cultivar Majus yielded the highest cantaloupe weight (30.52 Kg/plot) followed by the tolerant cultivar Royal 481 (27.5 Kg/plot). The first sowing date Mar.16 gave the highest mean production of cantaloupe yield of 12.22 Kg/plot. So, the best treatment was cultivation Majus or Royal 481 on the first sowing date Mar.16.

Introduction

Cantaloupe, *Cucumis melo* L. (Family: Cucurbitaceae) is one of the most important vegetable crops in Egypt, as it is cultivated under different environmental conditions, open fields, under plastic tunnels, and in greenhouses for local consumption and exportation. It is adapted to be cultivated to several types of soils either clay or sandy lands. *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) is one of the most devastating pests on cantaloupe greenhouses and open fields, adult and nymph attacks cause direct damage by continuous sucking of plant xylem (Bleicher *et al*., 2000) and also indirect damage, such as silverleaf (Lourenção *et al*., 2011), sooty mold development and virus transmission (Nagata *et al*., 2005), that reduce plant productivity.

A model of whitefly integrated pest management (IPM) has been proposed that conveniently organizes all *B. tabaci* control tactics into a multi-level, multi-component pyramid and defines major keys as "sampling" and "avoidance" (Ellsworth and Martinez-Carrillo, 2001). The planting seasons and plant varieties play an important role in the levels of the population density of pests. So, the planting date can be an effective pest management tactic because it results in asynchrony between the pests and crops (Albuquerque, 1993).

The current investigation targeted testing different cantaloupe cultivars cultivated on different dates to choose the best cultivar and date with low infestation and high production. This control strategy could be an alternative to chemical control.

Materials and methods

An area of about 1,400 m^2 represented the experimental area. Each plot (Replicate) measured 11.9 m^2 represented by three rows, cantaloupe seeds were sown directly in successive single rows on the southern edges of summer plantations. Rows are designed as 7 plants per row spaced 0.30 m apart. All the recommended agronomic practices for cantaloupe cultivation including irrigation, hoeing land, pruning, recommended fertilization, and harvesting adopted keeping the whole experimental plot area free from employing any insecticidal, fungicidal, and herbicidal plant protection measures during the whole period of study in summer (Starting on Mar. until Jul.). The natural infestation of whiteflies was evaluated in the experiments. Field experiments were conducted over three successive growing seasons (i.e., 2015, 2016, and 2017) on three different sowing dates; Mar.16, Apr.2, and 16. In order to evaluate the impact of sowing date on *B. tabaci* infestation and the resultant yield as well.

1. Experimental design and cultivation method:

The four tested cultivars; Arava, Majus, Darvina, and Royal 481 were planted on the three tested fortnight dates over the three years of study. The experimental area is represented by 4 cultivars x 3 plots x 3 sowing dates. All plots were set up under a complete randomized block design (CRBD). Cantaloupe fruits were picked out from each sowing date and weighed separately in order to be estimated and compared with each other.

2. Data analysis:

All the obtained data during the trials over the three growing seasons were subjected to analysis by using SAS Institute (1988) program. Duncan's multiple range test was used to obtain the mean separation and arrange cultivars according to their degree of infestation by B. tabaci eggs and nymphs at the level of 5 % of probability. The data of sowing dates of cantaloupe were analyzed in two ways analysis of variance and means were

separated by Duncan Multiple Range Test.

Results and discussion

The seasonal mean counts of eggs and nymphs infesting the four cantaloupe cultivars sown in the recommended sowing date Mar.16 and the post recommended dates; Apr.2 and Apr.16 were tabulated in Tables (1-9). The obtained results revealed that the population density of *B. tabaci* and the resultant yield were largely affected by both sowing date and cantaloupe cultivars.

1. Oviposition preference of *Bemisia tabaci* in relation to cantaloupe sowing date and cultivars over three seasons:

Data shown in Table (1) indicated the seasonal mean number of *B. tabaci* eggs over 2015. Majus cultivar recorded the lowest mean numbers (4.5 eggs/leaf) and Arava cultivar (5.6 eggs/leaf) over the three tested sowing dates. However, Royal 481 suffered from the highest number of eggs in the three sowing dates 11.7 eggs/leaf, followed by Darvina at 10.2 eggs/leaf [LSD= 1.2] $P<0.01$. Concerning the sowing date, it was clear from the calculated data that cantaloupe cultivars were planted on the third date; Apr. 16 had the lowest numbers (5.43 eggs/leaf). However, the second sowing date (Apr. 2) expressed the highest number of eggs (10.81 eggs/leaf). Moreover, the first sowing date (Mar. 16) showed a moderate eggs number (7.72 eggs/leaf) [LSD= 1.03] at $P<0.05$.

Table (1): *Bemisia tabaci* means the number of eggs/leaves on the four cultivars over three summer plantation sowing dates (2015).

Cultivar	Sowing date			Seasonal Mean
	Mar. 16	Apr.2	Apr. 16	
Arava	5.6	7.3	3.8	5.6 c
Majus	4.9	5.9	2.7	4.5 c
Darvina	10.02	13.3	7.33	10.2b
Royal 481	10.36	16.73	7.9	11.7a
Seasonal mean	7.72 b	10.81 a	5.43 c	
F. value	9.2*			25.9**
LSD	1.03			1.2

Means in columns or rows followed by the same letter are insignificantly different at $P < 0.05$.

In the year 2016, data presented in Table (2) showed a similar trend. The lowest infested cultivar was Majus (2.8 eggs/leaf) followed by Arava (3.5 eggs/leaf). Whereas, Darvina and Royal 481 were the most suffered (6.3 and 6.7eggs/leaf, respectively) ($P<0.05$). In other words, the sowing date; Apr. 2 had the highest eggs compared to the other tested dates. Whereas, Mar. 16 showed a moderate number of *B. tabaci* eggs with a seasonal mean of 4.5 eggs/leaf. However, on Apr. 16 harbored the lowest egg numbers (2.77 eggs/leaf).

Table (2): *Bemisia tabaci* means the number of eggs/leaves on the four cultivars over three summer plantation sowing dates (2016).

Cultivar	Sowing date			Seasonal Mean
	Mar. 16	Apr. 2	Apr. 16	
Arava	3.02	5.6	1.78	3.5 b
Majus	2.01	4.7	1.7	2.8 c
Darvina	6.15	9.05	3.8	6.3 a
Royal 481	6.8	9.5	3.8	6.7 a
Seasonal mean	4.5 b	7.21 a	2.77 c	
F. value	26.8**			35.4**
LSD	0.5			0.6

Means in columns or rows followed by the same letter are insignificantly different at $P<0.05$.

In the third season of 2017, Darvina and Royal 481 cultivars manifested high eggs (7.56 and 8.9 eggs/leaf, respectively). On the

contrary, low eggs number were shown on Arava and Majus (3.91 and 3.02 eggs/leaf, respectively). All the tested cultivars had high oviposition preference when sown on Mar.16 (8.9 eggs/leaf). However, the number of moderate eggs was recorded on Apr. 2 (6.21 eggs/leaf). The lowest was shown on Apr. 16 (2.4 eggs/leaf) (Table 3).

Table (3): *Bemisia tabaci* means the number of eggs/leaves on different cultivars over three summer plantation sowing dates (2017).

Cultivar	Sowing date			Seasonal Mean
	Mar. 16	Apr. 2	Apr. 16	
Arava	5.2	4.69	1.87	3.91b
Majus	3.91	3.98	1.16	3.02 b
Darvina	12.4	7.42	2.81	7.56 a
Royal 481	14.1	8.74	3.9	8.9 a
Seasonal mean	8.9 a	6.21 b	2.4 c	
F.value	9.8*			12.8**
LSD	1.2			1.4

Means in columns or rows followed by the same letter are insignificantly different at *P*<0.05

Concerning the average of eggs /leaf over the three studied years altogether on the four tested cultivars across the three tested sowing dates, significant differences were clearly observed. The results for cultivars in Table (4) showed that the low numbers of *B. tabaci* eggs were recorded in Majus followed by Arava (3.44 and 4.32 eggs/leaf, respectively). However, Darvina and Royal 481 had high eggs number (8.03 and 8.54 eggs/leaf, respectively) LSD=1.13 (*P*<0.05). There were highly significant differences between the three tested sowing dates, Apr. 2 recorded the highest numbers of eggs followed by Mar.16 with moderate eggs number at LSD= 0.98 (7.04 eggs/leaf). Delaying the sowing date to Apr.16 led to a low egg count with an average of 3.13 eggs/leaf over three seasons. From the above mentioned results, it can be concluded that the best treatment to escape adults egg laying was on Apr. 16 followed by Mar.16.

Table (4): Average of *Bemisia tabaci* eggs/ leaves on the four cultivars over 2015, 2016, and 2017 three summer plantation sowing dates.

Cultivar	Sowing date			Seasonal mean
	Mar. 16	Apr. 2	Apr. 16	
Arava	4.61	5.86	2.48	4.32 b
Majus	3.61	4.86	1.85	3.44 b
Darvina	9.52	9.92	4.65	8.03 a
Royal 481	10.42	11.66	3.53	8.54 a
Seasonal mean	7.04 b	8.1a	3.13 c	15.56**
F. value	9.46*			
LSD	0.98			1.13

Means in columns or rows followed by the same letter are insignificantly different at *P*<0.05

2. Nymphal infestation of *Bemisia tabaci* in relation to cantaloupe sowing date and cultivars over three seasons:

Regard the tabulated data in Table (5) represented the infestation rates with nymphs /leaf over 2015 in three sowing dates was low on the Majus cultivar (9.33 nymphs/leaf). However, a moderate infestation was recorded on the leaves of Arava (11.45 nymphs/leaf). The heaviest infestation was on Darvina and Royal 481cultivars (16.92 and 16.4 nymphs /leaf, respectively). The obtained results revealed that planting cultivars on Apr. 2 led to heavy infestation (16.72 nymphs/leaf) followed by Mar. 16

(13.15 nymphs /leaf). However, delaying the planting of cantaloupe to Apr. 16 led to lowest nymphs infestation/leaf with seasonal mean population of (10.7 nymphs/leaf) [LSD=1.1] $P<0.05$.

Table (5): *Bemisia tabaci* means the number of nymphs/leaves on the four cultivars over three summer plantation sowing dates (2015).

Cultivar	Sowing date			Seasonal Mean
	Mar.16	Apr. 2	Apr.16	
Arava	9.76	14.83	9.77	11.45b
Majus	9.27	10.84	7.8725	9.33c
Darvina	17.36	20.42	12.98	16.92a
Royal 481	16.21	20.81	12.19	16.4a
Seasonal mean	13.15 b	16.72 a	10.7 c	
F. value	10.6**			27.2**
LSD	1.1			1.24

Means in columns or rows followed by the same letter are insignificantly different at $P<0.05$

In the second season (2016), the nymphs infestation on Majus and Arava was low (8.5 and 8.03 nymphs/leaf) compared to Darvina and Royal 481cultivars (14.9 and 13.23 nymphs/leaf, respectively). The obtained results in Table (6) were the same compared to the previous season. The mean seasonal population was slight by delaying the sowing date to Apr. 16 where it was 7.1 nymphs/leaf [LSD= 2.03]. On the contrary, the high nymphal infestation was recorded on Apr. 2 (15.3 nymphs/leaf). The intermediate infestation rate was on Mar. 16 (11.1 nymphs/leaf) [LSD=1.8].

Table (6): *Bemisia tabaci* means the number of nymphs/leaves on the four cultivars over three summer plantation sowing dates (2016).

Cultivar	Sowing date			Seasonal Mean
	Mar. 16	Apr. 2	Apr. 16	
Arava	6.8	12.3	6.34	8.5b
Majus	6.34	11.8	5.9	8.03b
Darvina	18.32	17.49	8.89	14.9a
Royal 481	13.11	19.48	7.1	13.23a
Seasonal mean	11.1 b	15.3 a	7.1 c	
F. value	7.33*			8.6*
LSD	1.8			2.03

Means in columns or rows followed by the same letter are insignificantly different at $P<0.05$

As shown in Table (7) the means of population density of the *B. tabaci* nymphs in the third season (2017) of the four tested cultivars were highly significant different between the tested cultivars [LSD=1.4]. The low infestation was recorded on Arava and Majus (6.2 and 5.64 nymphs/leaf, respectively). On the other hand, Darvina cultivar harbored the highest nymphal infestation (13.4 nymphs/leaf), followed by Royal 481 cultivar (11.4 nymphs/leaf). Regarding the effect of three tested sowing dates on nymphs infestation, the obtained results confirmed the previous studied years. A slight infestation was recorded on Apr. 16 with a seasonal mean population of 5.94 nymphs/leaf. Whereas, the cultivation of cantaloupe on Apr.2 led to a high infestation rate of *B. tabaci* as 11.85 nymphs/leaf compared to the first and the third dates. The recommended date; Mar.16 showed the moderate nymphal infestation of 9.7 nymphs/leaf.

Table (7): *Bemisia tabaci* means the number of nymphs/leaves on the four cultivars over three summer plantation sowing dates (2017).

Cultivar	Sowing date			Seasonal Mean
	Mar. 16	Apr. 2	Apr. 16	
Arava	6.42	12.4	3.91	6.2 c
Majus	5.9	8.11	2.9	5.64 c
Darvina	16.1	15.74	8.5	13.4 a
Royal 481	11.02	15.31	8.42	11.4 b
Seasonal mean	9.7 b	11.85 a	5.94 c	
F. value	7.57*			22.27**
LSD	1.215			1.4

Means in columns or rows followed by the same letter are insignificantly different at *P*<0.05

Data in Table (8) showed the average of *B. tabaci* nymphs infesting cantaloupe cultivars and on three sowing dates over the three studied seasons. There was a highly significant difference between the tested cultivars i.e., the low infested cultivars with nymphs were Majus (7.67 nymphs/leaf) followed by Arava (9.2 nymphs/leaf). The high infestation rate during the three sowing dates was recorded on Darvina (15.1 nymphs/leaf) followed by Royal 481 (13.74 nymphs /leaf) [LSD= 1.4] $P < 0.01$. Concerning the sowing date, there was a highly significant difference between the three tested sowing dates ($P<0.01$), i.e., the mean population density of *B. tabaci* nymphs decreased as cultivars sown on Apr.16 (7.9 nymphs/leaf). The cultivation of cantaloupe on Apr. 2 led to the highest infestation rates of nymphs (14.97 nymphs/leaf). However, the moderate infestation rate was recorded on Mar. 16 (11.4 nymphs/leaf) [LSD=1.2].

Table (8): Average of *Bemisia tabaci* nymphs/leaf on different cultivars over 2015, 2016, and 2017 three summer plantation sowing dates.

Cultivar	Sowing date			Seasonal mean
	Mar. 16	Apr. 2	Apr. 16	
Arava	7.66	13.2	6.67	9.2 c
Majus	7.17	10.25	5.6	7.67 d
Darvina	17.26	17.9	10.1	15.1 a
Royal 481	13.45	18.53	9.24	13.74 b
Seasonal mean	11.4 b	14.97 a	7.9 c	
F. value	11.8**			20.1**
LSD	1.2			1.4

Means in columns or rows followed by the same letter are insignificantly different at *P*<0.05.

3. Interaction between cantaloupe cultivars and sowing date on the resultant yield:

Results in Table (9) showed the means of cantaloupe weight produced during the three sowing dates; Mar.16, Apr. 2, and Apr.16 in the summer plantation season of 2015. The lowest infested cultivar Majus yielded the highest cantaloupe weight (6.02 kg/plot) followed by Royal 481 cultivar which produced a weight of 3.885 Kg/plot. Arava and Darvina had the lower production yield of 1.74 and 2.6 Kg/plot, respectively. However, there wasn't a significant difference among the tested cultivars .Results in the subsequent Table (9) cleared that, the weight of cantaloupe considerably varied among the tested sowing dates. In this sense, cantaloupe seeds are sown on the closest sowing date Mar. 16 which had a moderate infestation led to the highest mean production of

cantaloupe yield 12.22 Kg/plot. On the contrary, sowing seeds on the latest sowing date; Apr. 16 yielded 6.05 kg/plot. However, Apr. 2 had the lightest cantaloupe weight with a mean yield of 4.25 Kg/plot.

Table (9): Mean of yield production (Kg.) per plot of cantaloupe cultivars over three summer plantation sowing dates (2015).

Cultivar	Seasonal mean of weight (Kg.) in sowing date/ plot				Total weight (Kg) from 3 plots
	Mar. 16	Apr. 2	Apr. 16	Seasonal Mean	
Arava	6.55	2.6	5.5	4.9	44.055
Majus	15.7	8.8	6.02	10.2	91.55
Darvina	11.9	1.74	3.8	17.44	46.71
Royal 481	14.73	3.855	8.9	5.8	88.81
Seasonal mean	12.22 a	4.25 c	6.05 b	9.6	271.125
F. value	7.94*			5.008	-
LSD	1.7			-	-

Means in columns or rows followed by the same letter are insignificantly different at *P*<0.05

The obtained results clearly indicated that different sowing dates (Mar.16, Apr. 2 and Apr. 16) affected *B. tabaci* egg laying and nymphal infestation on the four tested cultivars. The second sowing date (Apr. 2) received higher numbers of deposited eggs and nymphal infestation than the other tested dates followed by the recommended sowing date (Mar. 16). However, the latest Apr.16 received the lowest egg numbers and nymphal infestation. Darvina followed by Royal 481 received heavy infestation on all three tested sowing dates. However, Arava and Majus received lower infestation levels of the whitefly on the same dates. Concerning cantaloupe weight, the highest weight of fruits was obtained from the first sowing date (Mar. 16) followed by the latest one. However, the second date gave the lightest weight probably due to the effect of heavy infestation. The results agreed with the results of Mohamed (2011) for the squash yield fruits over planting dates in relation to infestation with *B. tabaci*. Moreover, Abd El-Gawad (2008) revealed that were significant differences between the different planting dates on the infestation by *B. tabaci*. Our results were versus those obtained by Mohamed (2012) who found that the early planting of cucumber (Mar.15) harbored low *B. tabaci* infestation. Also, a similar investigation Shaalan (2014) in Egypt in fall plantation indicated that the early sowing date escape *B. tabaci* infestation. However, Saeed and Razaq (2014) indicated that there wasn't a significant difference in *B. tabaci* population among three different canola sowing dates. Helalia *et al*. (2011), stated that the earliest planting date produced a significantly high weight of the yield. Studying the effect of cantaloupe cultivars and the three tested sowing dates revealed that the best treatment was cultivation Majus or Royal 481 on Mar.16.

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