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(Original Article)

Response and Evaluation of some Mango Cultivars to Striped Mealybug, *Ferrisia virgata* (Cockerell) Infestation in Southern Egypt

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Abstract

This study aimed to evaluate the performance of some mango cultivars in response to the striped mealybug, *Ferrisia virgata* (Hemiptera: Pseudococcidae) infestation in Kom Omboo region, Aswan Governorate, southern Egypt, during 2022/2023 and 2023/2024 seasons. The results showed that *F. virgata* populations were present on all mango cultivars throughout the year. The susceptibility of these cultivars to *F. virgata* varied. Zebda mango cultivar had the highest number of mealybugs and was classified as highly susceptible to *F. virgata* infestation. Goleck and Hindi Bisinnara cultivars were found to be susceptible while Ewaise, Sediek, and Taimour cultivars showed relative resistance during both seasons. However, the Taimour cultivar showed the lowest estimates of *F. virgata* infestation during both seasons, so in the areas where mealybug infestations are high; this mango variety should be considered. Results reveal that the Zebda cultivar had the highest values of mean numbers of *F. virgata*, population growth rate, quantity ratio, attraction index, crowding density, relative abundance establishment rate, and prevalence index. All these parameters indicated that this cultivar was preferred by *F. virgata* individuals compared to the other mango cultivars during both seasons. In contrast, the non-preference index was significantly higher in the Taimour cultivar compared to other tested cultivars. A new IPM approach for the control of *F. virgata* may be developed with the aid of this data.

Keywords: *Attraction index, Mango cultivars, Mealybugs, Population estimates, Prevalence index*

Introduction

Mango, *Mangifera indica* L. (Anacardiaceae), is one of Egypt's most widely grown fruit crops (Elhalawany *et al*., 2023). These tropical fruit trees are well-known for producing luscious, delectable stone fruits. From flowering to ripening, mangoes usually take four to five months (Maklad *et al*., 2020). Mango varieties are prized for their mid-season maturity, low fiber content, strong spicy flavor, sweet and appealing aroma, and regular bearing (Abd El-Aziz *et al*., 2024).

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Numerous insect pests harm mango trees (Bakry 2009). Among them, the striped mealybug, *Ferrisia virgata* (Cockerell) (Hemiptera: Pseudococcidae), is considered one of the most destructive pests of mango trees (Ata *et al.*, 2019). This pest is a soft-bodied insect that is found all over the world (Nabil *et al.*, 2020). It is a widespread pest that invades a wide range of crop plants. The axils of the leaves, veins, stems, branches, shoots, flowers, and fruit are encased in cotton layers of white, waxy material secreted by the insect (Ata *et al.*, 2019).

Leaf discoloration, deformed or stunted growth in the foliage, shoots, and fruit, decreased fruit quality, and early drop, are all signs of infestations of the striped mealybug. Infested branches may exhibit dieback symptoms and look sickly. The pests create honeydew, a sticky material that builds up on leaves, branches, and fruits. This honeydew attracts ants and encourages the growth of sooty mold, a black fungus that covers the leaves. A mealybug infestation may be indicated by increased ant activity on a mango tree (Bakry, 2009).

Mealybugs cause direct and indirect harm to mango trees, resulting in low yield, decreased fruit quality and tree health. Also, 100% fruit drop and 80% defoliation are possible outcomes of severe infestations (Karar *et al.*, 2015). When the sap of the mango tree is removed, the plant's water and nutrient supply is disrupted, leading to nutrient shortages and limited development. As a result, plants become weaker, and their leaves can turn yellow (Bakry *et al.*, 2023). Viral infections can cause indirect harm, and severe infestations might result in early fruit loss (Golan *et al.*, 2015).

Damage from feeding can result in defoliation, yellowing of the leaves, decreased plant development, and plant mortality. Fruits may become less marketable if honeydew and sooty mold develop on them. The existence of mealybugs alone increases the production costs required to avoid or eliminate their presence on plants, even if there is no obvious damage to the plants. The striped mealybug is extremely challenging for growers to mitigate after it has become established in an orchard (Ara, 2015).

Three methods of host plant resistance include tolerance, antixenosis and antibiosis**.** Antixenosis refers to a plant's ability to deter insects from feeding, laying eggs, or settling on it. It focuses on deterring insects, and insects can overcome it. Antibiosis refers to the ability of a plant to negatively affect the growth, development, or survival of insects that feed on it. It affects the biology of insects and may lead to their death or reduced fitness. Resistant genotypes are routinely used to breed pest-resistant cultivated plant varieties in addition to maintain insect populations at an acceptable level (Chand, 2021).

Mealybugs prefer certain mango cultivars, just like other insect pests and their numbers may differ depending on the variety (Karar *et al.*, 2009). Mango plants respond differently to insect infestations depending on their physical traits or chemical composition of their leaves. The behavior and metabolic processes of the striped mealybug are greatly influenced by biochemical factors, whereas morphological aspects largely influence the feeding, activity, and ingestion mechanisms (Karar *et al.*, 2010). Through the presence of certain morphological traits and/or biochemical components, as well as genetic modification that may prevent harmful insects from feeding or laying their eggs, endemic hosts from the wild or cultivated plants may have a defense system to protect themselves from various attacking pests (Rani and Jyothsna, 2010).

To lessen the damage that mealybugs do to mango yield and quality, it is important to use an integrated pest management (IPM) strategy that includes resistant crop cultivars. (Sharma and Ortiz, 2002). Plant resistance to insect pests refers to a plant's development of a resistance-related trait that aligns with the interaction between the insect pest and the target plant (Chand, 2021).

IPM techniques may involve the use of resistant cultivars to determine the most efficacious mango cultivar for managing the striped mealybug. Since the Aswan region offers the best environmental conditions for growing mangos, the majority of mango types are grown there, especially in Kom Omboo province. The purpose of this study was to investigate the responses of various mango cultivars to infestations by *F. virgata*. In addition, the growth rate, dispersal, and attractiveness were assessed to determine which cultivar was most effective in reducing *F. virgata* populations over time.

Materials and Methods

1. Monitoring and population ecology of the striped mealybug on certain mango cultivars

Field experiments of various mango cultivars were conducted in a private mango grove which was about ten acres in the Kom Omboo region, Aswan, southern Egypt (24º30'55" N, 32º57'15" E) over two consecutive seasons (2022/2023 and 2023/2024). Aswan region is regarded as one of the greatest mango agricultural growing areas (14,340 acres) in southern Egypt, with an annual production of 43,738 tons of mango fruits from different varieties (Annual Reports of Statistical Institute and Agricultural Economic Research in Egypt 2021).

Six cultivars of mature mango trees (Zebda, Ewaise, Taimour, Goleck, Hindi Bisinnara, and Sediek), representing the highest economic value of mango cultivars in the Kom Ombo area, Aswan, were selected for this study. Before and throughout the experiment period, no pest control techniques were applied to the randomly chosen mango trees.

Every mango cultivar had six trees. All the randomly selected trees had regular development and were about the same age (10 seasons old). The trees, which had excellent physical growth, were managed using comparable horticultural techniques. Each sample consisted of 40 leaves randomly sampled per tree, totaling 240 leaves per cultivar. There were 34,560 leaves (i.e., 6 cultivars × 6 trees × 40 leaves × 24 sampling days) sampled during the season, for a total of 69,120 leaves across the two seasons.

Samples of mango leaves from tested cultivar varieties were randomly collected from all parts and layers of the tree, stored in paper bags, and transported to the laboratory, where they were examined under a stereo zoom Microscope (model: NTB-3A/C, power: 220 V 50HZ, made by Novel company, location: China) at a 10x magnification. The number of *F. virgata* individuals (nymphs and females) on both adaxial and abaxial sides of mango leaves were carefully counted and recorded, according to the day which the samples were examined approximately every two weeks.

2. Susceptibility degrees

According to Semeada (1985) and Nosser (1996), the examined mango cultivars were categorized into highly sensitive (HS), susceptible (S), relatively resistant (RR), moderately resistant (MR), and resistant (R) based on their sensitivity levels, as indicated in Table (1).

Table 1. Description and categorization of six mango cultivars to *F. virgata* infestation.

Description	Category
> than (MN + UC) > than 9.22 individuals per leaf in 2022/2023 > than 10.09 individuals per leaf in 2023/2024	Highly susceptible (HS)
From MN to (MN+UC). 5.30 to 9.22 individuals per leaf in 2022/2023 5.84 to 10.09 individuals per leaf in 2023/2024	Susceptible (S)
< than MN to (MN-UC). < than 1.38 to 5.30 individuals per leaf in 2022/2023 < than 1.59 to 5.84 individuals per leaf in 2023/2024	Relatively resistant (RR)
From < (MN-UC) to (MN-2UC). From < (-2.53) to (1.38) individuals per leaf in 2022/2023 From < (-2.66) to (1.59) individuals per leaf in 2023/2024	Moderately resistant (MR)
< than (MN- 2UC). < than -2.53 individuals per leaf in 2022/2023 < than -2.66 individuals per leaf in 2023/2024	Resistant (R)

Explanations: MN = general mean number of *F. virgata* individuals; range of change = (maximum number of *F. virgata* individuals per cultivar - minimum number of *F. virgata* individuals per cultivar), and UC = amount of change in cultivars.

3. Estimating population growth rate and indicators of attraction and spread

Population growth rate (PGR)

The maximum population size and growth rate of *F. virgata* were used to compare the six mango cultivars, and time to attain maximum number (N_t) was noted for each. According to El-Deeb *et al*. (2021), the population growth rate (PGR) was computed as follows:

$$PGR = (N_t - N_0) / \Delta t$$

Where

N_t = number of individuals recorded at the maximum count of the population per leaf.

N0 = initial number of individuals counted per leaf.

Δt = difference in time between Nt and N0.

Quantity ratio (*QR*)

It is defined as the number of pest individuals at each cultivar (*a*) divided by the number of pest estimates at all cultivars (*A*) by 100 (Tu *et al*., 2018) as follows:

$$QR = (a / A) \times 100$$

Mealybug Attraction Index (AI)

In this regard, A is the number of mealybugs in each mango cultivar, and M is the average population of mealybugs in all studied mango cultivars on each sampling date.

If *AI* is greater than one, it shows high preference (more sensitive); if *AI* is equal to one, it shows medium preference (medium resistance); and if *AI* is lower than one, it shows low preference (more resistant) (Krisnawati *et al.*, 2017). The equation is as follows:

$$\mathbf{AI} = \frac{\mathbf{2A}}{\mathbf{M+A}}$$

Mean crowding intensity (M*) (Lloyd, 1967)

In this equation, $\overline{X}$ and S^2 are the mean and variance of population estimates in each studied mango cultivar, respectively. The equation is as follows:

$$\mathbf{M^{*}} = \overline{\mathbf{X}} + \frac{\mathbf{S^2}}{\overline{\mathbf{X}} + \mathbf{1}}$$

Relative abundance establishment rate (RAER)

In this equation, Ci and Cn are respectively the total population of mealybugs in each sampling stage in the i-th to n-th digit of the length of the sampling season, and n is the number of sampling times (Latifian *et al.*, 2023). The equation is as follows:

$$\mathbf{RAER} = \frac{\sum \mathbf{Ci}}{\frac{\sum \mathbf{C_i} + \cdots \sum \mathbf{C_n}}{\mathbf{n}}}$$

Relative probability of mealybug occurrence (RPMO)

In this equation, m is the number of mealybugs in each mango cultivar, and M is the maximum number of mealybugs recorded in all studied mango cultivars at each sampling date (Ghaedi *et al.*, 2020). The equation is as follows:

$$\mathbf{RPMO = (m\ /\ M)}$$

Mealybug Non-preference Index (NPI)

Accordingly, R represents the average mealybug estimates in each cultivar relative to the average total mealybug estimates in the mango cultivars under study (Antônio *et al.*, 2011). The equation is as follows:

$$\mathbf{NBI} = [\frac{(\mathbf{100 - R})}{\mathbf{100 + R}}] \times \mathbf{100}$$

Mealybug Prevalence Index (PI)

Accordingly, T represented the average mealybug population in each cultivar in each sampling, and P represented the average mealybug estimate in all mango cultivars under study (Antônio *et al.*, 2011). The equation is as follows:

$$\mathbf{PI} = \frac{\mathbf{(T\text{-}P)}}{\mathbf{(T+P)}} \times \mathbf{100}$$

4. Principal component and cluster analysis

Principal Component Analysis (PCA) was used to illustrate the multidimensionality of mealybug estimates on tested mango cultivars in a scatterplot applying R software (R Core Team, 2023).

Based on the similarity matrix, a plot was made exhibiting the relationships between *F. virgata* estimates on tested mango cultivars using hierarchical clustering analysis (HCA) of the unweighted pairwise group method with arithmetic mean (UPGMA) based on the Euclidean distance between clusters using the PAST program (Hammer *et al*. 2001).

Statistical analysis

An ANOVA plus a Tukey's HSD test was used to compare means at a 5% significance level, and the general linear model procedures of SPSS software (1999) were used to analyze variance in the data.

Results

1. Numbers of *F. virgata* individuals per leaf on six mango cultivars

The number of *F. virgata* individuals per leaf was scored on all mango cultivars during the season. The mean ± SE numbers of *F. virgata* individuals per leaf for all mango cultivars were similar for first season (5.30 ± 0.31) and season 2 (5.84 ± 0.38) (Table 2), respectively. The mean number of *F. virgata* individuals counted for first season was significantly differed amongst the various mango cultivars (F= 162.02, df = 213; $P \leq 0.0000$; coefficient of variation= 27.04%) and season 2 (F= 78.48, df = 213; $P \leq 0.0000$; coefficient of variation = 33.77%). For both seasons combined, the mean number of *F. virgata* individuals counted was significantly different (F value = 14.25, df = 429; $P \leq 0.0000$; coefficient of variation = 30.92%) amongst the various mango cultivars.

The mean numbers the *F. virgata* individual mealybugs counted per leaf for Zebda cultivar during first season (9.33 ± 1.30) and second season (10.13 ± 1.37) were higher than the other mango cultivars. This species is more suited for feeding and egg-laying by *F. virgata* nymphs and adults; therefore, it was categorized as highly susceptible (H.S.). The mean numbers of mealybugs for Goleck and Hindi Bisinnara mango cultivars which were categorized as susceptible (S) were 7.13 ± 0.59 and 5.54 ± 0.53 individuals per leaf in 2022/2023 and 6.00 ± 0.84 and 6.96 ± 0.97 individuals per leaf in 2023/2024, respectively, as shown in Table 2

However, the Taimour mango cultivar was categorized as relatively resistant (R.R.) and had the lowest overall average number of *F. virgata* during the two seasons (first season: 1.96 ± 0.23; second season: 3.08 ± 0.47 individuals per leaf), respectively. This means that it is not a preferred feeding and/or egg-laying host for this mealybug pest. This cultivar should be promoted in areas where *F. virgata* infestation is high.

Ewaise and Sediek mango cultivars also demonstrated relatively resistant (R.R.) infestation levels, with an average of 3.88 ± 0.35 and 3.96 ± 0.39 individuals per leaf in first season and 3.88 ± 0.53 and 5.00 ± 0.66 in second season, respectively, as shown in Table 2 and Fig.1.

The mango Taimour cultivar appears to be less susceptible to *F. virgata* infestation compared to the mango cultivar Zebda which appears most preferred (Table 2).

The following is a descending ranking of the examined kinds based on their susceptibility

Zebda > Goleck > Hindi Bisinnara > Sediek > Ewaise > Taimour in 2022/2023

Zebda > Hindi Bisinnara > Goleck > Sediek > Ewaise > Taimour in 2023/2024

It is clear that the variability in *F. virgata* estimates on different mango cultivars may also result from a variety of factors, including morphological and biochemical characteristics of mango leaves, as well as differences in environmental conditions (temperature and relative humidity).

Table 2. Average numbers of *F. virgata* individuals per leaf and sensitivity degree category of certain mango cultivars over two successive seasons (2022/2023 and 2023/2024).

Mango cultivars	Average no. of *F. virgata* individuals per leaf ± S.E			
	First season (2022/2023)		Second season (2023/2024)	
	Mean ± SE	Sensitivity degree category	Mean ± SE	Sensitivity degree category
Zebda	9.33 ± 1.30 a	HS	10.13 ± 1.37 a	HS
Ewaise	3.88 ± 0.35 cd	RR	3.88 ± 0.53 bc	RR
Taimour	1.96 ± 0.23 d	RR	3.08 ± 0.47 c	RR
Goleck	7.13 ± 0.59 ab	S	6.00 ± 0.84 bc	S
Hindi Bisinnara	5.54 ± 0.53 bc	S	6.96 ± 0.97 ab	S
Sediek	3.96 ± 0.39 cd	RR	5.00 ± 0.66 bc	RR
Cultivar mean/year	5.30 ± 0.31 B		5.84 ± 0.38 A	

Mean ± values denoted by various letters in a column for the number of *F. virgata* individuals among six mango cultivars show statistically significant differences per year at $P< 0.05$ (Tukey's HSD test). Mean ± values and cultivar mean per year followed by the same capital letter across each column are significantly different at the 0.05 level of probability by Tukey's HSD test. Sensitivity degree categories: HS = highly susceptible; S = susceptible; RR = relative resistance.

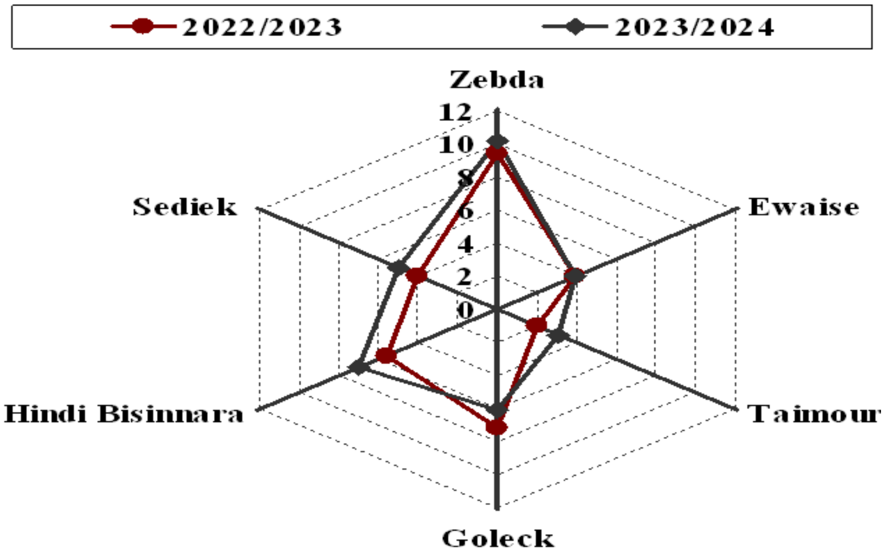

Fig. 1. Radar chart of the general average of *F. virgata* estimates per leaf on certain mango cultivars during two successive seasons (2022/2023 and 2023/2024).

2. Estimating population growth rate and indicators of attraction and spread

According to data in Table 3, the Zebda cultivar showed the highest values for population growth rate, quantity ratio, crowding density, attraction index, relative abundance establishment rate, relative probability of mealybug occurrence, and prevalence index. This suggests that *F. virgata* individuals preferred the Zebda cultivar over other mango cultivars during both seasons. On the other hand, Zebda cultivar's non-preference index was considerably declining compared to the other mango cultivars examined.

Table 3. Various models were used to assess the attraction and spread indices of *F. virgata* per leaf in the evaluated mango cultivars over the (2022/2023) and (2023/2024) seasons.

Cultivars / Indices	Year	Zebda	Ewaise	Taimour	Goleck	Hindi Bisinnara	Sediek
No	2022/2023	5.00	2.00	1.00	3.00	4.00	2.00
	2023/2024	6.00	0.50	1.50	2.50	4.00	2.50
Nt	2022/2023	24.00	8.00	4.00	12.00	10.00	8.00
	2023/2024	26.00	9.00	9.00	14.00	18.00	11.00
Δt	2022/2023	120	150	150	120	150	120
	2023/2024	120	150	150	120	120	120
PGR	2022/2023	0.16	0.04	0.02	0.08	0.04	0.05
	2023/2024	0.17	0.06	0.05	0.10	0.12	0.07
A	2022/2023	9.33	3.88	1.96	7.13	5.54	3.96
	2023/2024	10.13	3.88	3.08	6.00	6.96	5.00
QR	2022/2023	29.36	12.19	6.16	22.41	17.43	12.45
	2023/2024	28.89	11.06	8.80	17.12	19.86	14.27
AI	2022/2023	1.28	0.84	0.54	1.15	1.02	0.86
	2023/2024	1.27	0.80	0.69	1.01	1.09	0.92
M*	2022/2023	16.80	6.02	3.89	9.87	8.38	6.34
	2023/2024	17.82	7.47	6.68	11.28	12.83	9.17
RAER	2022/2023	0.54	0.52	0.51	0.42	0.36	0.51
	2023/2024	0.59	0.39	0.49	0.42	0.57	1.10
RPMO	2022/2023	0.39	0.16	0.08	0.30	0.23	0.16
	2023/2024	0.39	0.15	0.12	0.23	0.27	0.19
NPI	2022/2023	49.56	49.82	49.91	49.66	49.74	49.81
	2023/2024	49.56	49.83	49.87	49.74	49.70	49.79
PI	2022/2023	27.57	-15.52	-46.03	14.70	2.24	-14.48
	2023/2024	26.84	-20.23	-30.89	1.35	8.74	-7.75

Explanations: N_0 = initial number of individuals counted per leaf; N_t = number of individuals recorded at the maximum count of the population per leaf; Δt = difference in time between Nt and N_0; PGR = population growth rate; A = number of individuals in each cultivar per leaf, QR = quantity ratio; AI = attraction index; M* = mean crowding intensity; RAER = relative abundance establishment rate; RPMO = relative probability of mealybug occurrence; NPI = non-preference index; PI = prevalence index.

The Taimour cultivar was not preferred by *F. virgata* individuals over other mango cultivars during both seasons, as evidenced by the lower estimates of average numbers of mealybug *F. virgata*, population growth rate, quantity ratio, attraction index, crowding density, relative abundance establishment rate, relative probability of mealybug occurrence, and prevalence index (Table 3). In contrast, the non-preference index was significantly increasing in the Taimour cultivar compared to other tested mango cultivars.

The prevalence and attraction indices of *F. virgata* on various mango cultivars are displayed in Fig. 2. Zebda cultivar showed the highest values of the attraction index and the lowest estimate of the prevalence index, while the Taimour cultivar showed the lowest values of the attraction index and the highest estimate of the prevalence index (Fig. 2).

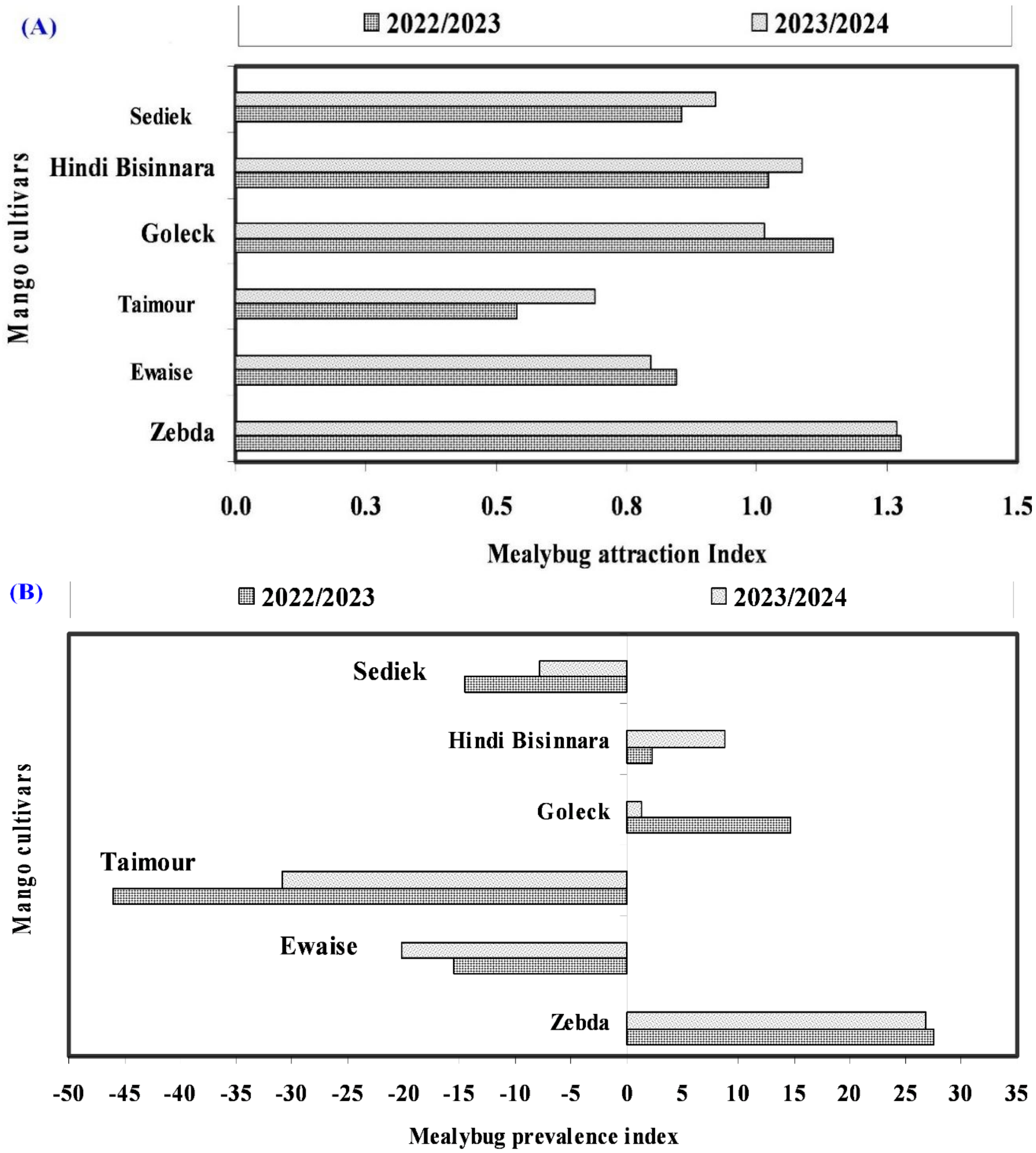

Fig 2. The estimated attraction (A) and prevalence (B) indices of *F. virgata* on various mango cultivars in the seasons (2022/2023) and (2023/2024). In the Fig. (2. B): An cultivar value on the x-axis that is positive (higher than zero) indicates that this cultivar is preferred. Conversely, a negative x-axis value (less than zero) indicates that the cultivar is not preferred.

3. Principal Component Analysis and Hierarchical Clustering Analysis

Principal Component Analysis (PCA) is a mathematical method that transforms many possibly correlated variables into a new set of uncorrelated variables called principal components (Wang and Battiti, 2005). The principal component analysis showed that tested mango cultivars were highly affected by *F. virgata* counts. The first two components of the PCA accounted for 90.48% of the total variance, whereas PCA1 accounted for 84.27% and PCA2 accounted for 6.57%, as presented in Fig. 3.

It was observed that the first component (PCA1) was negatively correlated with the Zebda cultivar with *F. virgata* abundance (Fig. 3). Interestingly, the PCA2 was positively correlated with the following cultivars (Ewaise, Taimour, Goleck, Hindi Bisinnara, and Sediek) with *F. virgata* estimates.

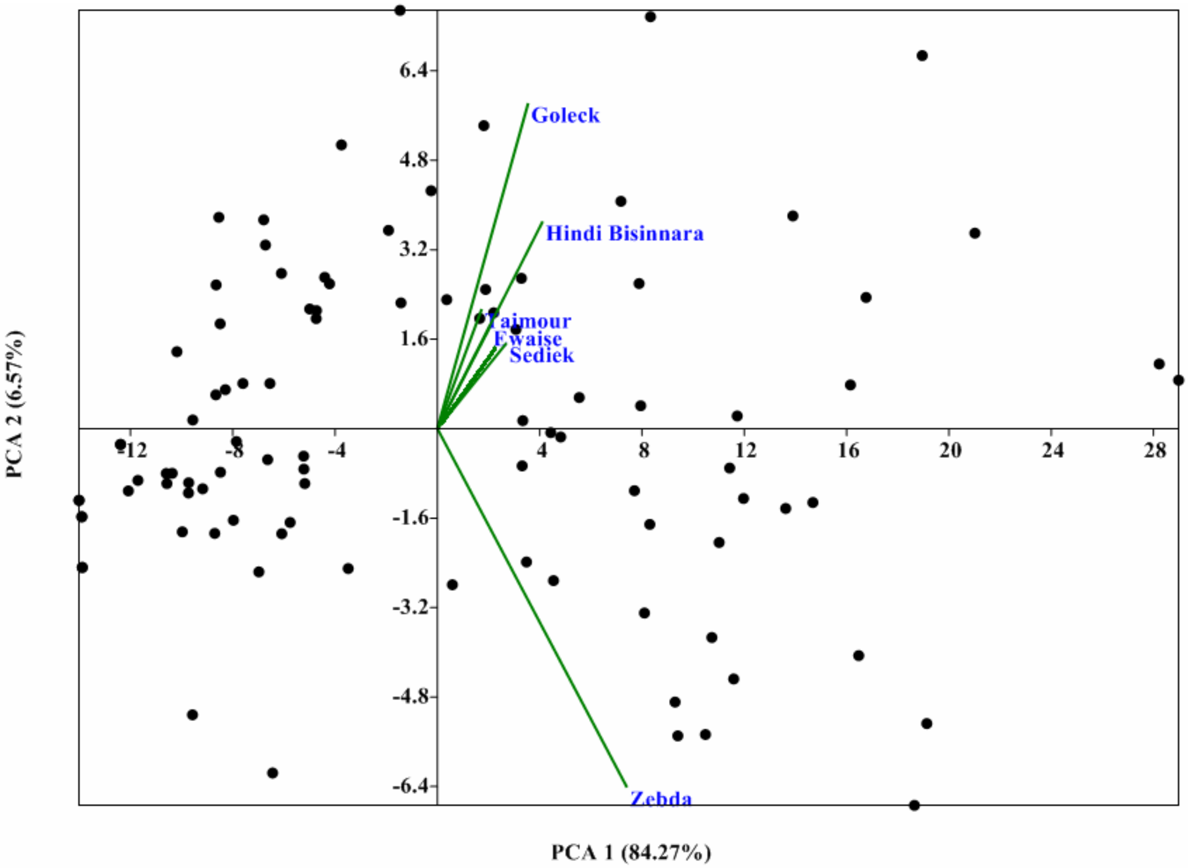

Fig 3. Principal component analysis (PCA)-based biplot for *F. virgata* estimations on six mango cultivars based on estimates of *F. virgata* pooled over two seasons.

The cluster tree of mango cultivars was confirmed based on the estimates of *F. virgata* into four groups as follows (Fig. 4). Group 1: The Zebda cultivar was in a separate group. Group 2: The Goleck and Hindi Bisinnara cultivars seemed to form a very close grouping in the dendrogram. Group 3: The Taimour cultivar was in a separate group. Group 4: Ewaise and Sediek cultivars appeared to form a clustered group in the dendrogram.

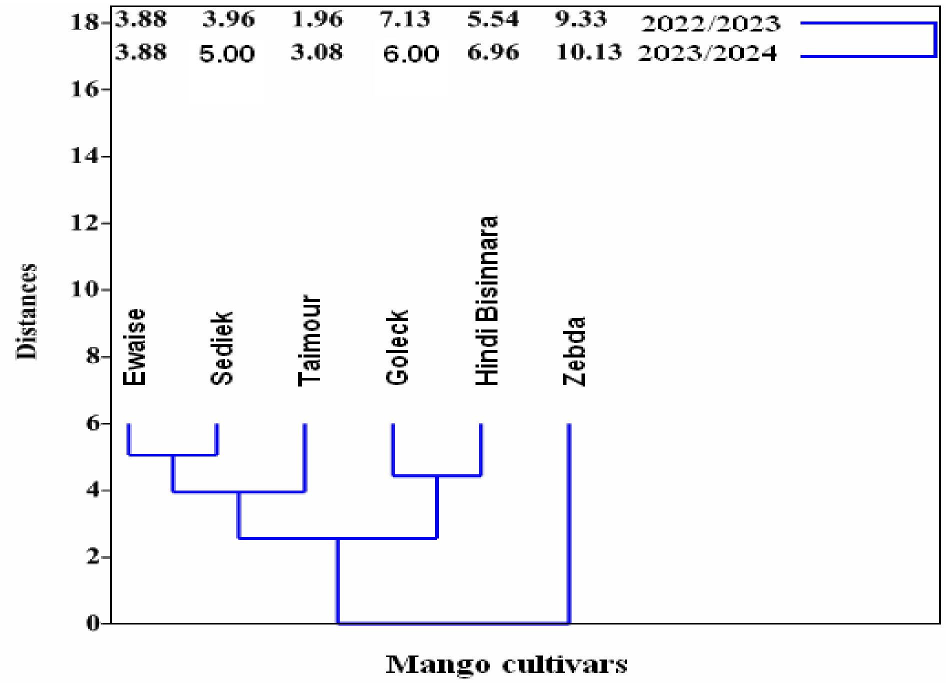

Fig 4. Dendrogram result of six mango cultivars categorized using a two-seasons average of *F. virgata* numbers.

Discussion

The present study aimed to evaluate the performance of some mango cultivars in response to infestation by the striped mealybug *Ferrisia virgata* (Hemiptera: Pseudococcidae) under natural field conditions on a private farm in the Kom Omboo region, Aswan Governorate, southern Egypt, during the seasons 2022/2023 and 2023/2024. Since the Aswan region offers the best conditions for growing mangoes, the majority of mango types are grown there, especially in Kom Omboo province. We also evaluated the growth rate, prevalence, and attractiveness of this pest to the tested cultivars.

All mango cultivars had *F. virgata* populations throughout the year. The cultivars' sensitivity to *F. virgata* varied widely. It was determined that the Zebda mango cultivar was very sensitive to infection by *F. virgata* and had the highest number of pest. It was discovered that the Hindi Bisinnara and Goleck cultivars were sensitive. The cultivars of Taimour, Sediek, and Ewaise demonstrated a comparatively high level of resistance during both seasons. In regions where mealybug infestation was prevalent, the Taimour cultivar of mango displayed the lowest estimates of *F. virgata* infestation in both seasons.

Zebda cultivar is low in fiber, has a strong spicy flavor, and produces an aromatic odor (Mohamed, 2024), which could be the main reason behind the heavy mealybug infestation and their preference for this variety.

Selim (2002) similarly investigated the vulnerability of five mango types (Hindy, Mabrouka, Dabsha, Kobania and Taimour) to infestation by two different armored scale insect pests, *Insulaspis pallidula* (Green) and *Aonidiella aurantii* (Mask.), in Egypt. In corroboration to our study about mealybugs, they found that the most vulnerable to both scale insect infestations were the Hindi Bisinnara cultivar, while Taimour cultivar demonstrated resistance. Also, Bakry (2009) investigated the differences in infestation levels of same-scale insects, *I. pallidula* and *A. aurantii* on four mango cultivars in Egypt, he found that Hindi Bisinnara and Goleck were moderately infested.

Similar to this present study, Karar *et al*. (2015) observed that scale insects displayed varying preferences for different cultivars (Ratul, Black Chaunsa, Fajri, Anwar Ratul, Sufaid, Malda, Sindhri, Dusehri, Langra Sensation and Tukhmi) of mangos. For the white mango scale insect, *Aulacaspis tubercularis* (Newstead), Bakry and Abdel-Baky (2020) in Egypt found that the Goleck mango cultivar was the most preferred, followed by Ewaise, Zebda, and Hindi Bisinnara. According to Bakry *et al*. (2020), in Egypt, the mango Ewaise cultivar had the highest population density of the mango shield scale, *Milviscutulus mangiferae* (Green) and was rated as extremely susceptible to infestation by the total population. The Balady variety was found to be relatively resistant, while the Zebda and Fagri Kalan mango varieties appeared to be susceptible.

Based on the overall population size of the plum scale *Parlatoria oleae* (Colvée), Bakry and Dahi (2020) reported that the Balady mango cultivar had the greatest number of individuals and was classified as highly vulnerable to infestation. The Ewaise and Goleck mango cultivars looked to be susceptible, while the Zebda cultivar emerged to be relatively resistant. On the other hand, the Sediek cultivar was evaluated as moderately resistant to pests throughout the year and had the lowest population estimates. According to Mokhtar (2022), the Fagri Klan mango cultivar had the greatest average total population of the seychelles scale, *Icerya seychellarum* (Westwood) in Egypt. However, no evidence of the scale insect infestation was found for the Skare and Ewaise cultivars, demonstrating a high degree of resistance similar to our study with mealybugs.

In this present study, the findings indicated that the Zebda cultivar had the highest average number of *F. virgata*, concerning population growth rate, quantity ratio, crowding density, attraction index, relative abundance establishment rate, and prevalence index. This suggests that *F. virgata* individuals preferred this cultivar over other mango cultivars during both seasons. However, in comparison with the other mango cultivars evaluated, the Taimour cultivar's non-preference index was much higher and demonstrated the highest resistance to populations of *F. virgata*.

Numerous factors, including the genetic variety among the farming methods or the chemical makeup of nutritional mineral components in the soil, may be responsible for the variance in how different mango cultivars—both sensitive and resistant ones—respond to mealybug infestation (Horgan *et al*., 2020).

For integrated pest control, insect-resistant plant cultivars are preferred for reducing insect pest damage by increasing plant tolerance/resistance to insect invasion. To lessen the damage caused by insect infestations, cultivars that are resistant to pests can be planted (Bakry and Abdel-Baky, 2020). A deeper understanding of the characteristics that either encourage or prevent insects from selecting host plants is essential for identifying low-susceptibility cultivars (Salem *et al*., 2006). There are several reasons why different mango trees are affected by insect infestation of the mealybugs among cultivated cultivars. Genetic variation and nutritional element components among mango species may be due to other causes (Solangi *et al*., 2014).

Genetic, ecological, physiological, pest-specific, and molecular variables affect how resistant certain mango cultivars are to pests. The physical characteristics, nutritional values, and amounts of secondary metabolites may also vary among the cultivars of host quality (Soufbaf *et al*., 2012). When using integrated pest management, crop rotation, agricultural practices, and biotechnological techniques, it is easier to implement resistant mango cultivars when these abiotic and biotic factors are elucidated and understood through field trials. The susceptibility of the host plant influences the development of pests and selecting a more resistant cultivar can reduce pest infestation, making it an additional component to be included in the IPM of mango trees in an agroecosystem.

Decision-makers of IPM programs may find the data gathered in this study useful for determining which of the mango cultivars are resistant, tolerant or susceptible to *F. virgata* populations over time. Results from this investigation can provide IPM specialists with information concerning resistant/tolerant cultivars that can be incorporated into a sound strategy for the pest management of *F. virgata* populations infesting mango cultivars. Therefore, by choosing to plant only these specific resistant/tolerant cultivars in mango groves, this practice would help to ensure a future of productivity and economic sustenance for the grower and potentially the country or nation.

Contribution of the Authors

Moustafa M. S. Bakry: designed the experiment, conducted the data collection, reviewed the manuscript, and performed the data analysis. Pasco B. Avery: composing, editing, and proofreading it. E.F.M. Tolba: wrote the draft, edited the methodology.

All co-authors have read and approved the manuscript before submission.

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استجابة وتقييم بعض أصناف المانجو للإصابة بحشرة البق الدقيقي المخطط (بق الفريزيا فرجاتا) في جنوب مصر.

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الملخص

هدفت هذه الدراسة إلى استجابة وتقييم بعض أصناف المانجو للإصابة بحشرة البق الدقيقي المخطط (الفريزيا فرجاتا) في منطقة كوم أمبو بمحافظة أسوان جنوب مصر خلال عامي 2023/2022، 2024/2023.

أظهرت النتائج، أن حشرة البق الدقيقي المخطط (الفريزيا فرجاتا) تصيب جميع أصناف المانجو على مدار العام. وتباينت حساسية هذه الأصناف للإصابة بالبق الدقيقي المخطط بشكل كبير.

سجل صنف المانجو الزبدة أعلى تعداد للبق الدقيقي وصُنف على أنه شديد الحساسية للإصابة بالبق الدقيقي المخطط. وجد أن صنفي الجولك والهندى بسنارة حساسين للإصابة بالحشرة وأظهرت أصناف المانجو العويسى والصديقة والتيمور مقاومة نسبية خلال كلا العامين.

ومع ذلك، أظهر صنف التيمور أقل تقديرات للإصابة بالبق الدقيقي المخطط خلال كلا العامين، لذلك في المناطق التي تنتشر فيها الإصابة بدرجة عالية بهذه الحشرة، يجب أخذ هذا الصنف من المانجو في الاعتبار.

كشفت النتائج، أن صنف المانجو الزبدة كان له أعلى قيم لمتوسط تعداد الحشرة، ومعدل نمو التعداد، ونسبة الكمية، ومؤشر الجذب، وكثافة الازدحام، ومعدل إنشاء الوفرة النسبية، ومؤشر الانتشار، وأشارت كل هذه المقاييس إلى أن هذا الصنف كان مفضلاً للإصابة بالبق الدقيقي المخطط مقارنة بأصناف المانجو المختبرة الأخرى خلال كلا العامين. على العكس، كان مؤشر عدم التفضيل أعلى بشكل ملحوظ في صنف المانجو التيمور مقارنة بالأصناف الأخرى التي تم اختبارها.

من خلال هذه البيانات، يمكن تطوير نهج جديد للإدارة المتكاملة للآفات لمكافحة حشرة البق الدقيقي المخطط (الفريزيا فرجاتا) على أشجار المانجو.

الكلمات المفتاحية: مؤشر الجذب، أصناف المانجو، البق الدقيقي، تقديرات التعداد، مؤشر الانتشار.