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RELATIONSHIP BETWEEN INFESTATION RATES BY *PARLATORIA OLEAE* (COLVEE), AND THE VEGETATIVE GROWTH AND NUTRITIONAL STATUS OF MANGO LEAVES

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ABSTRACT

A field study was carried out to evaluate the relationship between the infestation rate by *Parlatoria oleae* on the measurements of vegetative growth and nutritional status in seedy Balady mango leaves at Esna district, Luxor Governorate through the two consecutive seasons from the beginning of September, 2016 until mid-August, 2018. The two seasons data indicated that, the uninfested mango leaves had better vegetative growth measurements (shoot length, shoot thickness, number of leaves per shoot, leaf area and leaf index), physical properties (fresh weight, weight after one hour of drying in air, moisture and specific leaf area) and chemical properties (N, P, Mg, Zn, Fe, Mn and Cu) and crude protein content in mango leaves than those of the light and heavily infested leaves. While, in contrast, the dry weight, dry matter, loss moisture content and specific leaf weight, in addition to K and Ca contents increased significantly in the infested leaves as compared to the uninfested leaves. The two latter elements (K and Ca) may play a role in the defense mechanism of mango leaves against sap-sucking pests infestation. Also, the heavily infested leaves were considered the greatest infestation by pest and exhibiting the highest reduction in all studied measurements, except exposing the highest increasing in (dry weight, dry matter, loss in moisture content, specific leaf weight and K and Ca elements) than the lower rates of infestation (free and light). Generally, it seems that the population density of *P. oleae* during autumn months was the highest causing the greatest loss in studied measurements in autumn growth cycle of mango trees during the two seasons as compared with other growth cycles. The loss in the measured parameters was a summation of many factors including the rate of infestation, time of infestation, element contents, essential nutrients and the plant variety.

KEYWORDS

Parlatoria oleae, Mango, Growth rate and Element contents.

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INTRODUCTION

Mango (*Mangifera indica* L.) is one of the most important fruits in the tropics and subtropics. In Egypt, mango is occupies the third place in acreage after citrus and grapes. Mango fruits are considered as one of the most popular fruits for the Egyptian consumers due to its good flavour, delicious taste, nutritive value and other fruit attractive features (El-Said, 2006)[1]. Among several pests, infesting mango trees, *P. oleae* is considered one of the most main destructive pests of mango trees (Bakr *et al*., 2009)[2]. This pest injures the shoots, twigs, leaves, branches and fruits by sucking the plant sap with the mouth parts, causing thereafter deformations, defoliation, dryness of young twigs, dieback, poor blossoming, death of twig by the action of the toxic saliva and subsequently affecting the commercial value of fruits. Infestation causes conspicuous pink blemishes around the feeding sites of the scales (El-Amir, 2002)[3]. A characteristic symptom of infestation by this pest is the appearance and accumulation of its scales on attacked mango parts (Hassan *et al*., 2009)[4].

Mango trees exhibit variable reactions to the insect infestation depending on plant physical properties or chemical components of plant leaves. As bio-chemical factors, to a large extent, affect the behaviour and metabolic processes of the pest, while morphological factors mostly influence the mechanisms of locomotion, feeding, oviposition, ingestion and digestion of the pest (McAuslane, 1996)[5]. There are many factors, which affect the attraction of scale insect for feeding. One of these factors inside plant itself which makes the plant resistant or susceptible and may be genetic factors, or phenotypic due to differences in environmental factors such as the nutritional status of the soil (Dale, 1988)[6]. Insects have a great variation in their quantitative need for elements. This variation may reflect differences in metabolism. Mineral concentration is related to nutritional status of plants affecting their physiology and the herbivorous insects that feed on them in positive, neutral or negative ways (Dale, 1988)[6]. When any of these mineral elements becomes deficient, deficiency symptoms may not show up. Yet, in severe cases, the leaves and fruits do not develop normally and may stop growing.

Having information about density and changes in population of *P. oleae* throughout the season and determination of their periods of activity will help in management of this pest. As far as the writers know, few information concerning the effect of different infestation rates by *P. oleae* on the measurements of vegetative growth and nutritional status of mango leaves. So, it was found necessary to study this point in Luxor region where there is no reports about any similar research. Therefore, the objective of this study was to estimate the relationship between the population density of *P. oleae* and the some physical and chemical properties of mango trees during the two successive seasons of (2016/2017 and 2017/2018).

MATERIAL AND METHODS

This study was carried out in a private orchard of about five feddan located at Esna district, Luxor Governorate during the two seasons extending from beginning of the September, 2016 until mid-August, 2018, to clarify the effect of the different levels of infestation by *P. oleae* on the vegetative growth measurements and contents of nutritional status in seedy Balady mango leaves. Thirty seedy Balady mango trees were randomly, selected for sampling purpose from different parts of the orchard. Each level consisted of 10 trees. These samples were characterized by the following infestation levels according to (Salem *et al.*, 2015)[7].

Severe infestation

The scale existed on both leaf surfaces and harbored above 70 individuals per leaf.

Low infestation

The scale existed on both leaf surfaces and harbored from 10 to 70 individuals per leaf

Free of infestation (control)

Uninfested mango leaves.

All trees chosen for the experiment were of the same age (about ten years old) and of almost, the same size, shape, height and vegetative growth. All trees in this orchard received the normal agricultural practices, except for being free from any chemical application, before and during the period of investigation. Regular bimonthly samples consisted of 20 leaves, were randomly chosen per tree representing the four directions and heights of mango trees. Samples were picked regularly and were placed in polyethylene bags and immediately transferred to the laboratory where the leaves of each sample was inspected using a binocular microscope. Numbers of total alive *P. oleae* individuals on upper and lower surfaces of mango leaves were counted and recorded. The monthly mean numbers of total population of *P. oleae* per leaf was considered in this study to express the population size of pest.

The following measurements of vegetative growth and nutritional status of seedy Balady mango leaves were recorded in order to determine the correlations between the measured parameters in relation to the infestation rates by *P. oleae*.

Vegetative growth measurements

Ten new shoots were chosen from the ten labelled secondary branches per tree in the three growth cycles namely autumn cycle (flushes emerged during September and October), spring (flushes emerged during March, April and May) and summer cycle (flushes emerged during June, July and August) to measure their length (cm) and thickness (cm) and to count the number of leaves on them.

Measurements of leaf

Ten mature leaves per shoot (below panicles) in the three growth cycles were taken for calculating their length, width (cm) and leaf index.

- Leaf area (cm^2) was measured using the following equation as reported by Ahmed and Morsy (1999)[8].

Leaf area (cm^2) = 0.70 (L x W) - 1.06.

Where,

L: maximum length of leaf. W: maximum width of leaf.

- Leaf index = Length of leaf / Width of leaf.

In addition, the fresh samples of uninfested and infested leaves were picked and washed with tap water and then by distilled water to remove the dust and any other residues. Afterwards, these samples were dried in an electric oven at 70ºC for 48 hours. The fresh weight, dry weight and the weight after one hour of dryness in air for mango leaves were recorded in the three growth cycles in different rates of infestation.

- Specific leaf area (cm^2/g) = Leaf area / Leaf dry weight.

- Specific leaf weight (g/cm^2) = Leaf dry weight / Leaf area.

- The moisture and dry matter percentages were calculated using the following equations:

$$\text{- Moisture (\%)} = \frac{\text{Fresh weight – Dry weight}}{\text{Fresh weight}} \times 100$$

$$\text{- Dry matter (\%)} = \frac{\text{Average dry weight (g)}}{\text{Average fresh weight (g)}} \times 100$$

- The loss in moisture percentage in leaf was recorded (According to Brainerd and Fuchigami, 1981)[9].

$$\text{- Loss in moisture (\%)} = \frac{\text{Fresh weight - Dry weight after 1 hour in air}}{\text{Fresh weight - Dry weight}} \times 100$$

Estimating the nutritional status in leaves

Twenty mature leaves from fruiting shoots in the spring growth cycle were taken from each tree in the beginning of September in 2017 and 2018 seasons. Leaf mineral contents, i.e. N, P, K, Ca, Mg and Fe were determined (on dry weight basis) in leaves of mango (According to Chapman and Pratt, 1961)[10]. The dry material was ground by using an electric mill and stored in a small paper bag for analysis. Plant materials were digested by using H_2SO_4 as recommended by Parkinson and Allen (1975)[11].

Total nitrogen (N) was determined by semi-micro Kjeldahl methods as described by Bremner (1965)[12]. Phosphorus was colorimetrically determined by using ascorbic acid according to the method described by John (1970)[13]. Potassium (K) was determined by flame-photometer according to Brown and Lilliland (1946)[14]. Calcium, magnesium and micro-elements, i.e. (zinc, iron, manganese and copper contents) were determined using the atomic absorption spectrophotometer on dry weight basis according to the procedures of Carter (1993)[15].

- The percentage of crude protein in the leaves was determined (on dry weight basis) was calculated by the formula of Winkleman *et al.* (1986)[16].

Crude Protein (%) = Nitrogen percent x 6.25

The amount of losses due to pest infestation was calculated according to the following equation:

$$\text{\% Loss} = \frac{A - B}{A} \times 100$$

Where, A= uninfested leaves B= infested leaves

Averages of total alive insect population and measurements of vegetative growth and contents of mineral in leaves were calculated by Excel sheets program.

To determine the relationship between the percentages of reduction in the measured parameters for mango leaves represented as dependent variable(y) and the different infestation rates by *P. oleae* represented independent factor (X) during the two successive seasons of (2016/2017 and 2017/2018).The simple regression was used to show the variability in percentages of reduction in the measured parameters that could be caused by pest during the different infestation levels. The equation of linear regression was calculated according to the following formula of Fischer (1950)[17] and Hosny *et al*. (1972)[18].

$Y = a \pm bx$

Where:

Y = Prediction value (Dependent variable)

a = Constant (y - intercept)

b = Regression coefficient

x = Independent variable

This method was helpful for demonstrating basic information about the amount of variability in the reduction percentages in the measured parameters, and also to find out the explained variance (E.V.%). Obtained data were subjected to statistical analysis using a complete randomized design. Means were compared according to LSD test at $P \leq 0.05$ to clarify the significance between obtained rates of infestation. All statistical analyses of the present data were carried out by computer (MSTATC Program software, 1980)[19].

RESULTS AND DISCUSSION

The obtained results are represented in (Table No.1), showing the monthly mean counts of *P. oleae* on seedy Balady mango leaves during 2016/2017 and 2017/2018 seasons. The seasonal means of *P. oleae* counts were 30.67 ± 0.80 and 36.15 ± 0.96 individuals for light infestation and 105.07 ± 2.54 and 119.78 ± 2.81 individuals for heavy infestation, respectively. The increase in *P. oleae* population density in the severe infestation as compared with the low infestation reached about 3.31 to 3.43% during the two seasons. Obtained data cleared, also, that the highest total population density of *P. oleae* was recorded during autumn (more active), while, the lowest values were observed during winter months (Table No.1).

Effects of *P. oleae* infestation rate on the vegetative growth

On physical properties of leaves

Data in (Tables No.2 and 3) show the measurements of vegetative growth in relation to infestation rate by *P. oleae*. The obtained results indicated that the effect was proportional the intensity of infestation. Effects may be explained as follows:

On the shoot length (cm)

Mean shoot length in the uninfested trees (free) was 17.82 and 17.11 cm (as a general average during the three growth cycles) compared to 16.50 and 15.96 cm for the light infested trees and 16.18 and 15.60 cm for the heavy infested trees by pest during the first and second seasons, respectively (Tables No.2 and 3). The reduction percentages in shoot length than healthy trees (control) reached 7.43 and 6.73% for light infestation and 9.20 and 8.83% for heavy infestation rates, respectively.

The difference in shoot length among free, light and heavily infestation trees was highly significant (L.S.D. values were 0.13 and 0.34) during the two seasons, respectively. Moreover, the highest percentages of reduction in shoot length in proportion to uninfested trees were 8.57 and 8.28% caused by light infestation and 10.3 and 10.0%, respectively for heavy infestation were recorded in autumn growth cycle as compared to the spring and summer growth cycles of mango trees.

The relationship between the percentages of reduction in shoot length on mango trees (Y) against the different *P. oleae* infestation rates represented as independent factor (X) are presented in (Table No.4). Statistical analysis of simple correlation showed insignificant positive correlations between the different infestation rates by pest and percentages of reduction in shoot mango length (r values were +0.52 and +0.39) during the two study seasons, respectively. The unit effect regression coefficient (b) indicated that an increase of one insect per mango leaf, would cause 0.02 % increase in the percentages of reduction in shoot length. Bakry and Abdel-Mageed (2014)[20] stated that the length of main shoot in the uninfested grapevine was 98.1 cm (as a general average of ten shoots per vine) compared to 93.5 cm (4.69% reduction) for the infested ones by *Planococcus ficus*.

Effect on shoot thickness (cm)

Data tabulated in (Tables No.2 and 3) revealed that the heavily infested trees had thinner shoot thickness (seasonality averages of 0.60 and 0.58 cm for the two seasons, respectively compared to 0.61 and 0.60 cm for the light infested trees and 0.63 and 0.65 cm, respectively for the uninfested trees. Thus showing reductions in shoot thickness in the heavy infested trees by 8.16 and 7.89%, respectively than those of the uninfested ones. These reductions were about 6.63 and 5.26% in case of the light infested trees. The differences among different infestation rates in shoot thickness on mango trees were highly significant (L.S.D. value was 0.02) (Tables No.2 and 3). Bakry and Abdel-Mageed (2014)[20] recorded that the thickness of cane of the infested grapevines with *Planococcus ficus* was reduced by 10.09% compared to those of the uninfested ones.

Data represented in (Table No.4), showed that the different infestation levels by pest had insignificant positive effect on percentages of reduction in thickness of shoots on mango trees, since the correlation coefficient (r values were +0.22 and +0.41) for the first and second seasons, respectively. The simple regression coefficient indicated that an increase by only one insect per mango leaf, would increase the percentages of reduction in shoot thickness by 0.02 and 0.03% for both the two seasons, respectively.

Effect on number of leaves per shoot

Results revealed more leaves (seasonality averages of 15.20 and 14.80 leaves/shoot), respectively than those of the heavy infested ones (14.07 and 13.60 leaves/shoot) and 14.40 and 13.97 leaves/shoot of the light infested trees, respectively. These values confirmed reductions in the number of leaves per shoot of the heavy infested trees by 7.46 and 8.11% than the uninfested ones, while the light infested trees lost about 5.26 and 5.63%. Statistical analysis of data showed highly significant differences in the number of leaves per shoot among the different infestation levels (L.S.D. values were 0.44 and 0.49) (Table No.2 and 3).

Regarding the data in (Table No.4) showed that, the effect of different infestation rates by pest were insignificantly positive (r values were +0.55 and +0.45) during the two seasons, respectively. The calculated regression coefficient (b) indicated that an increase of one insect per mango leaf, would increase the reduction percentages in number of leaves per shoot by 0.03 and 0.03% as calculated for the two seasons, respectively.

Effect of infestation on leaf dimensions

Effect on leaf area

As reported in (Table No.2 and 3) revealed that the heavy infested leaves had smaller leaf area (seasonality averages; 79.39 and 79.56 cm^2) compared to 91.53 and 91.83 cm^2 for the uninfested trees and 82.22 and 82.53 cm^2 for the light infested trees during the first and second seasons, respectively. These data indicated that the leaf area of the *P. oleae* heavily infested trees was reduced by 13.26 and 13.36% than the uninfested ones, while the light infested trees lost about 10.17 and 10.13% during the first and second seasons, respectively. These differences between the different infestation rates were highly significant (L.S.D. values; 1.48 and 1.52) (Table No.2 and 3).

(Table No.4) shows also, that the simple correlation (r) between the effect different infestation rates and the percentages of reduction in the leaf area was positively significant (r values; +0.76 and +0.68) during the first and second seasons, respectively. Also, the calculated regression coefficient (b) of both seasons data indicated that an increase of one insect per mango leaf, would increase the percentages of reduction in leaf area by 0.04 and 0.04 %, respectively. These results are generally in harmony with those of Mohamed and Asfoor (2004)[21] who studied the effect of *Aonidiella aurantii* infestation on orange leaf area; being they reported 12.4 and 18.25% reduction, respectively for Navel and Valencia orange. Also, Bakry and Abdel-Mageed (2014)[20] reported that the leaf area of the infested grapevines by *Planococcus ficus* were reduced by 3.45% compared to the uninfested ones.

Effect on leaf index

Leaf index is an important parameter in photosynthesis. Results presented in (Tables No.2

and 3) showed that the highest values were measured on uninfested mango leaves (the two season means were 4.64 and 4.65) than the heavy (4.51 and 4.50) and the light (4.53 and 4.54) infested ones during the two seasons, respectively. The reduction percentages of leaf index in proportion to uninfested leaves were 2.44 and 2.29% for light infestation and 2.76 and 3.24% for heavy infested leaves during the two seasons, respectively. Highly significant differences were found among different infestation levels in leaf index (L.S.D. values; 0.07 and 0.08) (Table No.2 and 3). As shown in (Table No.4), the calculated r values were positively significant, being +0.68 and +0.65 for the first and second seasons, respectively. Also, the simple regression coefficient values indicates that an increase of one insect per a mango leaf, would increase the reduction percentage in leaf index by 0.01 % for either of the two seasons, respectively.

Effect on specific leaf area (SLA)

Specific leaf area (SLA) is defined as the ratio of leaf area to dry weight. Specific leaf area (SLA) is one of the most widely accepted key for leaf characteristics used during the study of leaf traits. Data in (Tables No.2 and 3) revealed that uninfested leaves of mango had bigger specific leaf area (365.76 and 361.85 cm^2/g), followed by the light infested leaves (318.66 and 314.86 cm^2/g), while heavy infested leaves showed the least values of SLA (296.81 and 295.65 cm^2/g) as seasonality averages during the two seasons of study, respectively. Statistical analysis revealed highly significant differences among different infestation levels; L.S.D. values were 10.53 and 9.38, respectively. Under heavy infestation by pest, the reduction percentages in (SLA) reached about 18.85 and 18.30%, while these reductions were about 12.88 and 12.99% for the light infested trees comparing with healthy leaves for the two seasons, respectively. Bakry (2014)[22] stated that the leaflets of date palm from the infested trees by *Parlatoria blanchardii* lost about 16.6% of (SLA) compared the uninfested ones.

The calculated r values between different infestation rates were highly positively significant; being +0.87 and +0.84 during the two seasons, respectively. The calculated regression coefficient (b) indicated that an increase of one insect per mango leaf, would increase the reduction percentages in specific leaf area by 0.08 and 0.06% for either season, respectively (Table No.4).

Effect of infestation on leaf weight measurements

On fresh leaves weight

Healthy leaves had significantly heavier fresh weight (as general means of two seasons of 2.18 and 2.16 g, respectively than heavily infested leaves (2.03 and 2.00 g) or light infested leaves (2.06 and 2.05 g) (Table No.2 and 3). Statistical analysis indicated highly significant differences in the fresh weight of leaves between the different infestation rates (L.S.D. values; 0.04 and 0.03) for the two seasons, respectively. Thus, indicated that the fresh weight from the heavily infested leaves lost about 7.04 and 7.16%, opposed to 4.99 and 5.51% for the light infested leaves as compared with the uninfested leaves for either of the two seasons, respectively. As reported in (Table No.4), the correlation coefficient (r) between the different infestation rates and the percentages of reduction in the fresh weight for leaves were significantly positive (r values; +0.70 and +0.64). The unit effect regression coefficient (b) indicated that an increase of one insect per mango leaf, would increase the percentages of reduction in the fresh weight by 0.02 and 0.03% for both the two seasons, respectively. Moussa *et al.* (2012)[23] reported that the fresh weight from the infested date palm leaflets by *P. blanchardii* lost about 5.8% from their weight as compared with the uninfested leaflets.

Effect on the leaf weight after one hour of drying in air

As shown in (Table No.2 and 3), data confirmed that the uninfested leaves had the greater dry leaves weight after one hour in air (2.03 and 2.03 g), however, the lowest weight was measured in heavy infested leaves (1.89 and 1.88 g as general means of two seasons). While, the weight after one hour of drying in air for the light infested leaves was (1.92 and 1.93 g) for the two seasons, respectively. Infestation by *P. oleae* caused a significant reduction in their weight after one hour of drying in air by 5.67 and 5.10 % for the light infested leaves and about 7.22 and 7.33% in the heavy infested leaves during the two seasons, respectively. Data revealed that there were highly significant differences in the weight in dry leaves after one hour in air between the different infestation levels (L.S.D. values were 0.04 and 0.01 for the two seasons, respectively) (Table No.2 and 3).

Results in (Table No.4) revealed that, the simple correlation coefficient (r) between the different infestation rates by pest and the percentages of reduction in the weight after one hour of drying in air were significantly positive (r values; +0.67 and +0.70 for the first and second seasons, respectively). The calculated regression coefficient (b) indicated that an increase of one insect per mango leaf, would cause 0.02 and 0.03% reduction in the weight of leaf one hour after exposure to air for both the two seasons, respectively. Bakry (2014)[22] recorded that the *P. blanchardii* infested date palm leaflet lost about 6.7% of its weight after an hour exposure to air compared with the uninfested leaflet.

Effect of infestation on the leaf dry weight

The uninfested leaves of mango had lower dry weight (0.25 and 0.25 g) than the heavy infested leaves (two season means; 0.27 and 0.27 g) the light infested leaves was (0.26 g) for the two seasons, respectively (Table No.2 and 3). There were highly significant differences in the dry weight between the different infestation levels (L.S.D. value was 0.01) for each of the two seasons, respectively. Also, the dry weight of the heavy and light infested leaves was increased by 6.58 and 5.97% and about 2.94 and 3.34% as compared to the uninfested ones (Table No.2 and 3). In agreement with the present results, Moussa *et al.* (2012)[23] stated that the dry weight of the infested date palm leaflets by *P. blanchardii* was reduced by 2.9 % compared to the uninfested ones.

Data in (Table No.4) showed that, the correlation coefficient between the different infestation rates by pest and the percentages of reduction in the dry weight were significantly negative (r values were -0.70 and -0.75) for the first and second seasons, respectively. The regression coefficient (b) indicated that one insect per mango leaf, would decrease the percentages of reduction in dry weight by 0.05 and 0.03% for both the two seasons, respectively.

Effect on the specific leaf weight (SLW)

Specific leaf weight is an indicator of leaf toughness and photosynthesis velocity. Results in (Table No.2 and 3) revealed that uninfested leaves had less specific leaf weight (0.0028 and 0.0028 g/cm^2) than the heavy infested ones (0.0034 and 0.0034 g/cm^2 as general means of the two seasons, respectively). These values in light infested leaves were 0.0032 g/cm^2 in every season. The increase in (SLW) was about 22.88 and 22.34 % in heavy infested leaves and about 14.61 and 15.03% for light infested ones as compared with the uninfested ones through the two seasons, respectively. Also, highly significant differences among different infestation rates in SLW were calculated (L.S.D. values; 0.0003 and 0.0003, respectively). Bakry (2014)[22] reported that the increase in (SLW) was about 19.4 % in infested date palm leaflets by *P. blanchardii* compared with the uninfested ones.

The simple correlation coefficient (r) between the different infestation rates by pest and the percentages of reduction in the specific leaf weight were negative and highly significant (r values were -0.78 and -0.86). The calculated regression coefficient (b) indicated that infestation by one *P. oleae* individuals per mango leaf, would decrease the percentages of reduction in specific leaf weight by 0.11 and 0.09% for the two seasons, respectively (Table No.4).

Effect of infestation on the dry matter content

Dry matter refers to material remaining after removal of water. Data represented in (Table No.2 and 3) cleared that infestation with *P. oleae* to mango leaves exhibited higher percentage of dry matter by (13.25 and 13.51%) in heavily infested leaves and (14.74 and 14.39%) compared with the uninfested ones for the two seasons, respectively. As well, the mean percentages of dry matter in the uninfested leaves were lower (11.55 and 11.81%) than those of the light infested leaves (12.59 and 12.85%). There were highly significant differences between the different infestation rates (L.S.D. values were 0.32 and 0.33; (Table No.2 and 3). Also, insect infestation caused increases of the percentage of dry matter in light infested leaves by 8.99 and 8.80% thought the two seasons, respectively. Bakry (2014)[22] estimated 3% increase in the dry matter of the infested date palm leaflets by *P. blanchardii* compared with the uninfested ones.

The relationship between the different infestation rates by pest and the reduction percentages in the dry matter of mango leaves proved as significantly negative (r values; -0.67 and -0.72, respectively). The simple regression coefficient (b) indicated that one insect per mango leaf, would decrease the percentages of reduction in the dry matter content of mango leaves by 0.08 and 0.07% during the two seasons, respectively (Table No.4).

Effect of infestation on the moisture content

The moisture content reflects the amount of water present in leaves. Data in (Table No.2 and 3) revealed that the uninfested leaves had the highest moisture content (88.45 and 88.19%), followed by light infested leaves (87.41 and 87.15%) and heavy infested leaves (86.75 and 86.49%) for the two seasons, respectively. Statistical analysis of data revealed highly significant differences in percentages of moisture contents in leaves harbored different infestation levels (L.S.D. values; 0.32 and 0.33) for the two seasons, respectively. The reduction percentages of moisture content were 1.17 and 1.18% for light infestation and 1.92 and 1.90% for heavy infestation through the first and second seasons, respectively. Moussa *et al.* (2012)[23] stated that the moisture content of the infested date palm leaflets by *P. blanchardii* lost about 2.4% as compared with the uninfested leaflets.

(Table No.4) showed that the correlation coefficient (r) values between the different infestation levels by pest and the percentages of reduction in the moisture of leaves were significantly positive (+0.70 and +0.73) in the first and second seasons, respectively. Also, the unit effect regression coefficient (b) indicated that an increase of one *P. oleae* individuals per mango leaf, would increase the percentages of reduction in the moisture content in mango leaves by 0.01% for each of the two seasons, respectively.

Effect of infestation on the lost in moisture content

Data in (Table No.2 and 3) indicated that heavy infestation of mango leaves by *P. oleae* caused the highest loss of moisture (8.06 and 7.12%), followed by light infested leaves (7.98 and 6.97%). While, the healthy uninfested leaves showed the lowest loss percentage of moisture (7.71 and 6.78%). The statistical analysis of data revealed insignificant differences among different infestation rates (Table No.2 and 3).

As regarded to the effect of insect infestation on the moisture content loss, data revealed that invasion by *P. oleae* led to 4.60 and 4.95% increase moisture content loss for heavy infested leaves and about 3.57 and 2.79% increase in loss in the light infested leaves during the two seasons of study, respectively (Table No.2 and 3). Moussa *et al.* (2012)[23] stated that the increasing was about 16.2 % in infested date palm leaflets by *P. blanchardii* compared with the uninfested ones.

Results in (Table No.4) revealed that, the simple correlation coefficient between the effect of different infestation rates by pest on the lost moisture content for leaves were significantly negative (r values; -0.68 and -0.66). Also, the calculated regression coefficient (b) indicated that one insect per mango leaf, would decrease the percentages of reduction in lost moisture content in leaves by 0.07 and 0.04% for the two seasons, respectively.

Effect of infestation on the chemical components

Effect of infestation on macro- element contents

On the percentage of Nitrogen in leaves

Nitrogen is the most essential mineral element for plant growth and development and one of the most important factors in development of herbivore populations. The adequate absorption of nitrogen can increase vegetative growth, photosynthesis and high yield. Data presented in (Table No.5) showed that the uninfested leaves had the highest percentages in N content (1.99 and 1.96%), followed by the light infested leaves about (1.86 and 1.86%), while heavy infested leaves had the lowest N content in leaves (1.77 and 1.78%). Statistical analysis of data revealed highly significant differences in the N content among different infestation levels by pest (L.S.D. values; 0.03 and 0.05) for the two seasons, respectively. As well, the heavily infested leaves lost about 10.98 and 9.35% of N content, opposed to 6.60 and 4.95% decrease for the light infested leaves as compared with the uninfested leaves. Salman *et al.* (2012)[24] recorded that the infested date palm leaflets by *P. blanchardii* lost about 7.65% of N content as compared with the uninfested leaflets.

Data in (Table No.6) indicated that, the effect of different *P. oleae* infestation levels by pest on the percentages of reduction in N content in leaves were highly significantly positive (+0.85) during the first season and significantly positive effect (+0.67) during the second season. Also, the calculated regression coefficient (b) indicated that an increase in infestation by one *P. oleae* individuals per a mango leaf, would increase the reduction percentages in N content in leaves by 0.06 and 0.05% for both the two seasons, respectively.

Effect on the percentage of Phosphorus in leaves

Data presented in Table (5) showed that the heavily infested leaves had the least percentage in P content (0.24 and 0.25 %). In contrast, healthy leaves had the highest percentage in P content (0.27%) during the two seasons of study, respectively. Highly significant differences among the different infestation rates by *P. oleae* were calculated (L.S.D. values; 0.01 and 0.02) through the two seasons, respectively. It was also noticed that the insect infestation exhausted about 9.75 and 9.16% in the P content for the heavy infested leaves and about (7.32 and 7.33%) for light infested leaves (Table No.5). Bakry (2014)[22] recorded that, the infested date palm leaflets by *P. blanchardii* lost about 8.9% from P content as compared with the uninfested leaflets.

The results in (Table No.6), showed the correlation coefficient (r) between the different infestation rates by pest and the percentages of reduction in the P content were significantly positive (r value; +0.66) for the first season and highly significant positive relation (r value; +0.86) through the second season. As well, the calculated regression coefficient (b) indicated that an increase of one insect per mango leaf, would increase the percentages of reduction in the P content in leaves by 0.06 and 0.05% for both the two seasons, respectively. In similar studies, Wu *et al.* (2004)[25] reported that *Nilaparvata lugens* infestation reduced the nutrient uptake of rice plants particularly phosphorous and potassium. The decrease in P is closely related to many physiological and biochemical process in plants such as protein biosynthesis, growth, and photosynthesis (Wang, 2000)[26].

Effect on the percentage of Potassium in leaves

Potassium is an important solute in expanding cells. Also, expansive growth is very sensitive to K deficiency. In addition, potassium has a great role in controlling cell water content and carbohydrates biosynthesis and mobilization in plant tissues (Harhash and Abdel-Nasser, 2007)[27]. As shown in Table (5), data confirmed that the highest K content (0.42 %) was estimated in the heavy infested leaves, followed by (0.41%) for the light infested leaves in each of the two seasons. While, the uninfested leaves recorded the least percentages of K (0.38 and 0.39%) during both the two seasons, respectively. Analysis of variance indicated highly significant differences among tested infestation levels in the K content (L.S.D. values; 0.01 and 0.01), respectively. Data showed that this *P. oleae* invasion increased potassium content by 10.53 and 9.04% increase for heavy infested leaves and about 7.11 and 6.98% increase for the light infested leaves during the two seasons of study, respectively (Table No.5).

The correlation coefficient values (r) between the different infestation rates and the reduction percentages in K content in mango leaves were significantly negative (r values; -0.74 and -0.69) for the first and second seasons, respectively (Table, 6). Moreover, the unit effect regression coefficient (b) indicated that one *P. oleae* individuals per mango leaf, would decrease the percentages of reduction in K content in leaves by 0.05 and 0.02% for both the two seasons, respectively Potassium content may play a role in the defense mechanism of plant. Myers and Gratton (2006)[28] stated that the K content in leaves affect plant quality and may play an important role in the soybean aphid population dynamics.

Effect on the percentage of Calcium in leaves

Data presented in (Table No.5), clear that the least percentage of Ca was measured in the uninfested leaves (1.18 and 1.22 %) in the two seasons of study, respectively. On contrary, the heavily infested leaves contained the highest percentage of Ca (1.27 and 1.29%). Also, there were highly significant differences between different infestation rates and the Ca leaf content (L.S.D. values; 0.03 and 0.02). As well, the percentages of Ca content proved to be significantly higher in infested leaves as compared the healthy ones. The increase was about 7.57 and 5.63% in heavy infested leaves and 4.69 and 3.41% in light infested leaves during the two seasons of study, respectively (Tables No.5).

Results in (Table No.6) revealed that, the simple correlation coefficient (r) between the effect of different infestation rates by pest and the percentages of reduction in the Ca content in leaves were highly significantly negative (r value; -0.75) for the first season and significantly negative (r value; -0.67) through the second season. Also, the calculated regression coefficient (b) indicated that an increase of one insect per mango leaf, would decrease the percentage of reduction in Ca content in leaves by 0.06 and 0.03% for the two seasons data, respectively. It is obvious that, K and Ca contents in mango leaves may play a role in the defense mechanism of plant against the pest. These results agree with those of Salman *et al.* (2012)[24] who reported that K and Ca contents may be play a role in the defense mechanism of date palm leaflets against infestation by *P. blanchardii.*

Effect on the percentage of Magnesium in leaves

Results tabulated in (Table No.5) revealed that the uninfested leaves had the highest percentage of Mg content (0.34 and 0.35%), followed by the light infested leaves about (0.33 and 0.33%), while heavy infested leaves had lowest Mg content in leaves (0.31 and 0.31%) as a general means of the two seasons of study, respectively. The differences among the different infestation rates by *P. oleae* were highly significant (L.S.D. values; 0.02 and 0.01, respectively). It was also noticed that the insect infestation exhausted about 8.91 and 9.25% in the Mg content for the heavy infested leaves and about (4.82 and 5.49%) for light infested leaves during both the two seasons, respectively (Table No.5). Bakry (2014)[22] recorded that, Mg content from the infested leaflets by *P. blanchardii* lost about 5.08% as compared with the uninfested ones.

Statistical analysis of simple correlation (Table No.6) showed that highly significant positive correlations between the different infestation rates by pest and the percentages of reduction in the Mg content in mango leaves (r values; +0.89 and +0.78) during both seasons of study, respectively. As well, the simple regression coefficient (b) indicated that an increase by one insect per mango leaf, would increase the reduction percentages in Mg content by 0.06 and 0.04 % for the two seasons, respectively. Silva *et al.* (2005)[29] reported that the insects need considerable amounts of potassium, phosphorus and magnesium in their diets, whereas, little calcium, sodium and chloride are required. Also, significant variation in element concentrations and aphid populations was observed among different sampling times and cultivars.

Effect of infestation on micro-element contents

On the leaf content of Zinc (mg.kg^{-1})

Data presented in (Table No.5) revealed that heavily infested leaves by *P. oleae* were less in Zn content than that in uninfested ones (29.60 and 29.90 vs. 33.09 and 33.09 mg.kg^{-1}) two season means, respectively. Moreover, different infestation rates varied, highly significantly, in the Zn content (L.S.D. values; 0.41 and 0.33). Heavily infested leaves by *P. oleae* caused reduction by 10.55 and 9.66% in the Zn content, and by 6.73 and 6.42% for light infested leaves during both the seasons, respectively (Table No.5).

Data in (Table No.6), indicated highly significant positive effects between the different infestation rates by pest and the percentages of reduction in Zn content in mango leaves (r values; +0.97 and +0.86), respectively. Also, the calculated slopes of the regression (b) indicated that an increase by one insect per mango leaf, would increase the reduction percentages in Zn content by 0.05 and 0.04 %, respectively.

Effect on the leaf content of Iron (mg.kg^{-1})

Data in (Table No.5) indicated presence of highest content of Fe in the uninfested leaves (193.40 and 194.10 mg.kg^{-1}) than the heavy infested (173.10 and 175.90 mg.kg^{-1}) and the light infested ones (183.25 and 184.30 mg.kg^{-1}, respectively). Statistical analysis confirmed highly significant differences in the Fe content among different infestation rates by pest (L.S.D. values; 3.18 and 2.24, respectively). As well, the Fe content from the heavy infested leaves lost about 10.50 and 9.38% and that in light infested leaves lost 5.25 and 5.05%, respectively than that recorded in the uninfested leaves (Table No.5).

According to the calculated simple correlation coefficient (r) between the different infestation levels and the Fe percentages of reduction, there were highly significant positive effects (r values; +0.92 and +0.91, respectively). The calculated regression coefficient (b) indicated that an increase by an *P. oleae* individuals per mango leaf, would increase the reduction percentages in the Fe content by 0.07 and 0.05% for both the two seasons, respectively (Table No.6).

Effect on the leaf content of Manganese ($mg.kg^{-1}$)

As deduced from (Table No.5) the uninfested leaves of mango had the highest values in Mn content (28.47 and 28.70 $mg.kg^{-1}$), followed by light infested leaves (26.95 and 27.65 $mg.kg^{-1}$) as two season means, respectively. However, the heavy infested leaves exhibited the smallest Mn content (25.50 and 26.00 $mg.kg^{-1}$, respectively). Statistical analysis revealed highly significant differences among different infestation rates by pest (L.S.D. values; 1.17 and 0.92). It was clear that the infestation with *P. oleae* caused remarkable reductions in Mn content in the heavy infested (10.43 and 9.41%) and the light infested (5.34 and 3.66%) leaves (Table No.5).

Statistical analysis revealed that differences in reductions in Mn content due to different infestation rates were highly significantly positive (+0.82 and + 0.84, respectively). The calculated regression coefficient (b) indicated that an increase in infestation by an individuals per mango leaf, would increase the reduction percentage in Mn content in leaves by 0.07% for either of the two seasons, respectively (Table No.6).

Effect on the leaf content of Copper ($mg.kg^{-1}$)

Data in (Table No.5) confirmed that the uninfested leaves had the greatest content of Cu content (6.35 and 6.49 $mg.kg^{-1}$) than the heavy infested ones (5.70 and 5.77 $mg.kg^{-1}$) and the light infested leave (5.83 and 6.00 $mg.kg^{-1}$, respectively). The differences in Cu content between the different infestation rates were highly significant (L.S.D. values; 0.18 and 0.16) during the two seasons, respectively. It was also noticed that the insect infestation exhausted about 10.24 and 11.03% in the Cu content for the heavy infested leaves and (8.20 and 7.48%) for light infested leaves during both the two seasons, respectively (Table No.5).

The results in (Table No.6), showed the correlation coefficient (r) between the different *P. oleae* infestation rates and the percentages of reduction in the Cu content in leaves were significantly positive effect (r value; +0.71) for the first season and highly significantly positive relation (r value; +0.78) during the second season. As well as, the calculated regression coefficient (b) indicated that increase in infestation by one individuals per mango leaf, would increase the reduction percentages in the Cu content in leaves by 0.05% for either of the two seasons, respectively (Table No.6). Bakry (2014)[22] reported that the infested date palm leaflets by P. *blanchardii* lost about 2.07, 2.16, 3.20, 6.7% from Fe, Zn, Mn and Cu contents, respectively as compared with the uninfested leaflets.

Effect of infestation on crude protein

Data in (Table No.5) revealed that the uninfested leaves were found to contain, significantly, the highest percentage of crude protein (12.41 and 12.24%), followed by light infested (11.59 and 11.63%) and heavily infested leaves (11.05 and 11.09% for the two seasons, respectively). Moussa *et al.* (2012)[23] recorded that the infested date palm leaflets by *P. blanchardii* lost about 7.65 % from crude protein as compared with the uninfested leaflets.

The statistical analysis revealed highly significant differences in percentages of crude protein content between different infestation rates (L.S.D. values; 0.17 and 0.30 during the two seasons, respectively). Also, the heavily infested leaves lost about (10.98 and 9.35 %) and about (6.60 and 4.95 %) of crude protein for the light infested leaves as compared with the uninfested leaves (Table No.5).

As shown in (Table No.6), the effect of different *P. oleae* infestation rates on the percentages of reduction in crude protein in leaves were highly significantly positive (r value; +0.85) during the first season and significantly positive (r value; +0.67) during the second season. Also, the calculated regression coefficient (b) indicated that an increase in infestation by one individuals per mango leaf, would increase the percentages of reduction in crude protein in leaves by 0.06 and 0.05% for both the two seasons, respectively.

These results agree with those of Khattab (2007)[30] who stated that the infested cabbage leaves exhibited low level of soluble protein compared with uninfested ones, to which might be attributed the decline in its biosynthesis that resulted from drain age of assimilates such as amino acids towards the phloem sucking aphid. Emam (2009)[31] found that infestation with rose aphid, *Macrosiphum rosae* (L.) (Hemiptera: Aphididae) caused change in the protein banding pattern (amino acids) on rose plants

The present results revealed that the uninfested mango leaves were better in the vegetative growth properties (shoot length, shoot thickness, number of leaves per shoot, leaf area and leaf index), physical properties (fresh weight, weight after one hour of drying in air,

moisture and specific leaf area) and chemical properties (N, P, Mg, Zn, Fe, Mn and Cu) and crude protein content in mango leaves than those of the light and heavy infested leaves. While, in contrast, the dry weight, dry matter, loss moisture content and specific leaf weight, in addition to K and Ca contents increased significantly in the infested leaves as compared to the uninfested ones. Moreover, the element contents (K and Ca) may play a role in the defense mechanism of mango leaves against sap-sucking pests infestation. Hafida (2006)[32] stated that potassium, sodium and magnesium contents in both citrus varieties (Lemon and Clementine) were inversely proportional to insect invasion with *Parlatoria ziziphi*.

From the explained results, it could be concluded that the *P. oleae* heavily infested leaves exhibited the highest reduction in all studied measurements, except those of (dry weight, dry matter, loss moisture content, specific leaf weight, K and Ca elements) than the free and light infested leaves.

Table No.1: Monthly mean numbers of total alive *P. oleae* individuals per mango leaf at Esna district, Luxor Governorate during 2016/2017 and 2017/2018

Season	Date of inspection	Mean number of individuals per leaf ± S.E.			
		Light infestation		Heavy infestation	
		First season	Second season	First season	Second season
Autumn	**Sept.**	33.50 ± 0.92	33.16 ± 0.78	120.60 ± 2.63	125.60 ± 2.52
	Oct.	43.92 ± 0.70	44.83 ± 0.49	151.39 ± 2.15	146.07 ± 1.92
	Nov.	30.52 ± 0.59	48.94 ± 0.90	133.12 ± 2.55	154.73 ± 2.83
	Average	**35.98 ± 1.14**	**42.31 ± 1.31**	**135.03 ± 2.72**	**142.13 ± 2.65**
Winter	**Dec.**	19.99 ± 0.27	33.33 ± 0.46	95.43 ± 1.30	147.45 ± 2.04
	Jan.	18.03 ± 0.23	18.13 ± 0.14	69.05 ± 0.94	69.52 ± 0.47
	Feb.	14.79 ± 0.19	16.82 ± 0.39	61.14 ± 0.78	60.48 ± 1.50
	Average	**17.60 ± 0.42**	**22.76 ± 1.41**	**75.21 ± 2.78**	**92.49 ± 7.30**
Spring	**Mar.**	30.65 ± 0.70	29.13 ± 0.69	71.60 ± 1.65	112.52 ± 2.65
	April	33.19 ± 0.71	39.38 ± 0.86	106.46 ± 2.28	131.46 ± 2.88
	May	30.22 ± 0.58	35.61 ± 0.51	96.50 ± 1.79	103.89 ± 1.49
	Average	**31.35 ± 0.45**	**34.71 ± 0.88**	**91.52 ± 2.93**	**115.96 ± 2.53**
Summer	**June**	36.94 ± 0.34	43.94 ± 0.26	117.80 ± 0.69	139.80 ± 0.87
	July	41.61± 0.25	48.26 ± 1.13	136.59 ± 1.25	147.19 ± 2.11
	Aug.	34.71 ± 0.49	42.30 ± 0.62	101.20 ± 1.39	98.64 ± 2.31
	Average	**37.76 ± 0.65**	**44.83 ± 0.63**	**118.53 ± 2.87**	**128.54 ± 4.10**
General average		**30.67± 0.80**	**36.15 ± 0.96**	**105.07 ± 2.54**	**119.78 ± 2.81**

Table No.2: Effect of the different infestation rates by P. oleae, on the vegetative growth measurements of seedy Balady mango trees during the first season (2016/2017)

Growth cycles	Infestation level	Physical properties												
		Shoot length	Shoot thickness	Number of leaves	Leaf area	Leaf index	Fresh weight	Weight after hour	Dry weight	Specific leaf area	Specific leaf weight	Dry matter	Moisture	% Lost in moisture
Autumn	Free	17.50	0.66	15.00	91.65	4.68	1.99	1.85	0.23	403.75	0.0025	11.46	88.54	7.81
	Light	16.00 (8.57%)	0.61 (7.58%)	14.00 (6.67%)	81.77 (10.79%)	4.55 (2.86%)	1.86 (6.60%)	1.72 (6.77%)	0.23 (3.11%)	348.52 (13.68%)	0.0029 (15.67%)	12.65 (10.39%)	87.35 (1.34%)	8.12 (3.94%)
	Heavy	15.70 (10.3%)	0.60 (9.09%)	13.80 (8.00%)	79.09 (13.71%)	4.54 (3.04%)	1.84 (7.60%)	1.70 (7.81%)	0.25 (7.99%)	321.78 (20.30%)	0.0031 (25.33%)	13.40 (16.87%)	86.60 (2.18%)	8.22 (5.29%)
	L.S.D. at 5%	0.85 **	0.05 *	N.S.	3.18 **	N.S.	0.03 **	0.04 **	0.01 *	18.78 **	0.0003 **	0.79 *	0.79 *	N.S.
Spring	Free	18.02	0.63	15.20	88.10	4.67	2.26	2.11	0.26	336.45	0.0030	11.61	88.39	7.50
	Light	16.89 (6.2%)	0.60 (4.76%)	14.60 (3.95%)	79.41 (9.86%)	4.56 (2.39%)	2.15 (4.87%)	2.00 (5.02%)	0.27 (2.52%)	295.72 (12.11%)	0.0034 (13.72%)	12.50 (7.68%)	87.50 (1.01%)	7.72 (3.00%)
	Heavy	16.64 (7.66%)	0.59 (6.35%)	14.20 (6.58%)	76.76 (12.87%)	4.56 (2.55%)	2.11 (6.64%)	1.97 (6.75%)	0.28 (5.16%)	278.60 (17.19%)	0.0036 (20.75 %)	13.07 (12.59%)	86.93 (1.65%)	7.76 (3.42%)
	L.S.D. at 5%	0.26 **	N.S.	N.S.	2.83 **	0.10 *	0.10 *	0.10 *	N.S.	17.96 **	0.0003 **	0.49 **	0.49 **	N.S.
Summer	Free	17.94	0.67	15.40	94.84	4.56	2.30	2.14	0.27	357.06	0.0028	11.57	88.43	7.82
	Light	16.60 (7.47%)	0.62 (7.46%)	14.60 (5.19%)	85.48 (9.87%)	4.47 (2.07%)	2.18 (5.22%)	2.03 (5.36%)	0.27 (3.22%)	311.73 (12.70%)	0.0032 (14.62%)	12.61 (8.91%)	87.39 (1.17%)	8.11 (3.76%)
	Heavy	16.20 (9.70%)	0.61 (8.96%)	14.20 (7.79%)	82.34 (13.18%)	4.44 (2.68%)	2.14 (6.96%)	1.99 (7.17%)	0.28 (6.78%)	290.04 (18.77%)	0.0035 (22.97%)	13.28 (14.78%)	86.72 (1.93%)	8.21 (5.05%)
	L.S.D. at 5%	0.47 **	0.04 **	0.50 **	3.39 **	N.S.	0.12 *	0.11 *	N.S.	24.29 **	0.0003 **	0.64 **	0.64 **	N.S.
During the three growth cycles	Free	17.82	0.65	15.20	91.53	4.64	2.18	2.03	0.25	365.76	0.0028	11.55	88.45	7.71
	Light	16.50 (7.43%)	0.61 (6.63%)	14.40 (5.26%)	82.22 (10.17%)	4.53 (2.44%)	2.06 (5.51%)	1.92 (5.67%)	0.26 (2.94%)	318.66 (12.88%)	0.0032 (14.61%)	12.59 (8.99%)	87.41 (1.17%)	7.98 (3.57%)
	Heavy	16.18 (9.20%)	0.60 (8.16%)	14.07 (7.46%)	79.39 (13.26%)	4.51 (2.76%)	2.03 (7.04%)	1.89 (7.22%)	0.27 (6.58%)	296.81 (18.85%)	0.0034 (22.88%)	13.25 (14.74%)	86.75 (1.92%)	8.06 (4.60%)
	L.S.D. at 5%	0.31 **	0.02 **	0.44 **	1.48 **	0.07 **	0.04 **	0.04 **	0.01 **	10.53 **	0.0003 **	0.32 **	0.32 **	N.S.
Effect resulted		R	R	R	R	R	R	R	I	R	I	I	R	I

L.S.D.: Least significant difference; * significant for P<0.05; ** significant for P<0.01; N.S. = Not Significant; R= Reduction and I = Increase

Table No.3: Effect of the different infestation rates by P. oleae, on the vegetative growth measurements of seedy Balady mango trees during the second season (2017/2018)

Growth cycles	Infestation level	Physical properties												
		Shoot length	Shoot thickness	Number of leaves	Leaf area	Leaf index	Fresh weight	Weight after hour	Dry weight	Specific leaf area	Specific leaf weight	Dry matter	Moisture	% Lost in moisture
Autumn	Free	15.43	0.65	14.40	92.37	4.68	1.96	1.84	0.23	393.67	0.0025	12.00	88.00	6.73
	Light	14.15 (8.28%)	0.61 (6.15%)	13.60 (5.56%)	82.67 (10.50%)	4.56 (2.61%)	1.83 (6.17%)	1.73 (6.17%)	0.24 (2.57%)	343.48 (12.75%)	0.0029 (14.61%)	13.12 (9.23%)	86.88 (1.27%)	6.81 (1.29%)
	Heavy	13.88 (10.0%)	0.59 (9.23%)	13.00 (9.72%)	79.39 (14.06%)	4.53 (3.40%)	1.76 (10.0%)	1.65 (10.19%)	0.25 (5.84%)	319.61 (18.81%)	0.0031 (23.13%)	14.12 (17.67%)	85.88 (2.41%)	7.10 (5.52%)
	L.S.D. at 5%	0.64 **	0.04 *	N.S.	3.23 **	N.S.	0.04 **	0.04 **	0.01 **	11.93 **	0.0003 **	0.49 **	0.49 **	N.S.
Spring	Free	17.67	0.60	14.80	89.35	4.69	2.24	2.10	0.26	341.05	0.0029	11.71	88.29	6.91
	Light	16.62 (5.94%)	0.58 (3.33%)	14.00 (5.41%)	80.45 (9.96%)	4.58 (2.19%)	2.14 (4.46%)	2.01 (4.65%)	0.27 (3.28%)	297.61 (12.74%)	0.0034 (14.84%)	12.65 (8.01%)	87.35 (1.06%)	7.18 (3.93%)
	Heavy	16.35 (7.64%)	0.56 (6.67%)	13.80 (6.76%)	77.81 (12.91%)	4.54 (3.07%)	2.10 (6.47%)	1.96 (6.65%)	0.28 (5.92%)	280.24 (17.83%)	0.0036 (21.76%)	13.27 (13.27%)	86.73 (1.76%)	7.23 (4.96%)
	L.S.D. at 5%	0.62 **	N.S.	0.70 *	2.59 **	0.07 **	0.08 *	0.07 *	N.S.	21.02 **	0.0003 **	0.86 **	0.86 **	N.S.
Summer	Free	18.23	0.65	15.20	93.76	4.58	2.28	2.15	0.27	350.84	0.0029	11.73	88.27	6.71
	Light	17.10 (6.18%)	0.61 (6.15%)	14.30 (5.92%)	84.46 (9.92%)	4.48 (2.07%)	2.18 (4.49%)	2.05 (4.61%)	0.28 (4.06%)	303.50 (13.49%)	0.0033 (15.46%)	12.79 (9.05%)	87.21 (1.20%)	6.92 (3.12%)
	Heavy	16.56 (9.15%)	0.60 (7.69%)	14.00 (7.89%)	81.48 (13.09%)	4.43 (3.26%)	2.16 (5.37%)	2.03 (5.54%)	0.28 (6.12%)	287.08 (18.17%)	0.0035 (22.17%)	13.15 (12.14%)	86.85 (1.61%)	7.02 (4.65%)
	L.S.D. at 5%	0.70 **	0.03 **	0.50 **	3.56 **	N.S.	0.08 *	0.08 *	N.S.	23.39 **	0.0003 **	0.70 **	0.70 **	N.S.
During the three growth cycles	Free	17.11	0.63	14.80	91.83	4.65	2.16	2.03	0.25	361.85	0.0028	11.81	88.19	6.78
	Light	15.96 (6.73%)	0.60 (5.26%)	13.97 (5.63%)	82.53 (10.13%)	4.54 (2.29%)	2.05 (4.99%)	1.93 (5.10%)	0.26 (3.34%)	314.86 (12.99%)	0.0032 (15.03%)	12.85 (8.80%)	87.15 (1.18%)	6.97 (2.79%)
	Heavy	15.60 (8.83%)	0.58 (7.89%)	13.60 (8.11%)	79.56 (13.36%)	4.50 (3.24%)	2.00 (7.16%)	1.88 (7.33%)	0.27 (5.97%)	295.65 (18.30%)	0.0034 (22.34%)	13.51 (14.39%)	86.49 (1.9%)	7.12 (4.95%)
	L.S.D. at 5%	0.34 **	0.02 **	0.49 **	1.52 **	0.08 **	0.03 **	0.01 **	0.01 **	9.38 **	0.0003 **	0.33 **	0.33 **	N.S.
Effect resulted		R	R	R	R	R	R	R	I	R	I	I	R	I

Table No.4: Simple correlation, regression values and linear regression equation when the counts of the mean population density of P. oleae were plotted versus the percentages of reduction in each of the physical characteristics for mango leaves through out the two successive seasons (2016/2017 and 2017/2018)

Properties	Season	First season (2016/2017) r	b	S.E	T-test value	Y = a ± bx	E.V. %	Second season (2017/2018) r	b	S.E	T-test value	Y = a ± bx	E.V.%
Physical	Shoot length	0.52	0.02	0.01	1.70	6.67 + 0.02 x	26.59	0.39	0.02	0.02	1.21	5.76 + 0.02 x	15.52
	Shoot thickness	0.22	0.02	0.03	0.62	5.81 + 0.02 x	4.61	0.41	0.03	0.03	1.26	4.01 + 0.03 x	16.56
	Number of leaves	0.55	0.03	0.02	1.88	4.33 +0.03 x	30.50	0.45	0.03	0.02	1.43	4.42 + 0.03 x	20.34
	Leaf area	0.76*	0.04*	0.01	3.29*	8.95 + 0.04 x	57.50	0.68 *	0.04 *	0.02	2.65*	8.70 + 0.04 x	46.65
	Leaf index	0.68*	0.01*	0.00	2.62*	1.96 + 0.01 x	46.28	0.65 *	0.01 *	0.01	1.87 *	1.87 + 0.01 x	41.99
	Fresh weight	0.70*	0.02*	0.01	2.78*	4.88 + 0.02 x	49.10	0.64 *	0.03 *	0.01	2.38*	4.07 + 0.03 x	41.34
	Weight after hour	0.67*	0.02*	0.01	2.54*	5.07 + 0.02 x	44.61	0.70 *	0.03 *	0.01	2.66 *	4.14 + 0.03 x	49.07
	Dry weight	-0.70*	-0.05*	0.02	-2.79*	– 1.53 – 0.05 x	49.21	-0.75 *	-0.03 *	0.01	-3.01 *	–2.22 - 0.03 x	56.79
	Specific leaf area	0.87**	0.08**	0.02	4.87**	10.44 + 0.08 x	74.75	0.84**	0.06**	0.01	4.45**	10.70 + 0.06 x	70.80
	Specific leaf area	-0.78**	-0.11**	0.03	3.49**	–11.39 – 0.78 x	60.32	-0.86**	– 0.09**	0.02	4.70**	–11.82 – 0.86 x	73.33
	Dry matter	-0.67*	-0.08*	0.03	-2.57*	– 6.60 – 0.08 x	45.27	-0.72 *	-0.07 *	0.02	-2.78 *	– 6.5 - 0.07 x	52.31
	Moisture	0.70*	0.01*	0.00	2.81*	0.85 + 0.01 x	49.71	0.73 *	0.01 *	0.00	2.88 *	0.86 + 0.01x	53.91
	% Lost moisture	-0.68*	-0.07*	0.03	-2.61*	1.37 – 0.07 x	45.98	-0.66 *	-0.04 *	0.01	-2.51 *	–1.10 - 0.04 x	44.09

r = Simple correlation S.E = Standard error Y = a ± bx (Regression linear equation)
b = Simple regression E.V.% = Explained variance

Table No5: Effects of the plum scale insect, P. oleae infestation rates on leaf mineral contents (Macro- and Micro-elements) on seedy Balady mango trees during the two successive seasons (2016/2017 and 2017/2018)

Season	Infestation level	Leaf mineral contents: Macro-elements (%) N	P	K	Ca	Mg	Micro-elements (mg.kg^{-1}) Zn	Fe	Mn	Cu	Crude protein %
2016/2017	Free	1.99	0.27	0.38	1.18	0.34	33.09	193.40	28.47	6.35	12.41
	Light	1.86 (6.60%)	0.25 (7.32%)	0.41 (7.11%)	1.24 (4.69%)	0.33 (4.82%)	30.86 (6.73%)	183.25 (5.25%)	26.95 (5.34%)	5.83 (8.20%)	11.59 (6.60%)
	Heavy	1.77 (10.98%)	0.24 (9.57 %)	0.42 (10.53%)	1.27 (7.57%)	0.31 (8.91%)	29.60 (10.55%)	173.10 (10.50%)	25.50 (10.43%)	5.70 (10.24 %)	11.05 (10.98%)
	L.S.D. at 5%	0.03 **	0.01 **	0.01 **	0.03 **	0.02 **	0.41 **	3.18 **	1.17 **	0.18 **	0.17 **
2017/2018	Free	1.96	0.27	0.39	1.22	0.35	33.09	194.10	28.70	6.49	12.24
	Light	1.86 (4.95%)	0.25 (7.33%)	0.41 (6.98%)	1.26 (3.41%)	0.33 (5.49%)	30.97 (6.42%)	184.30 (5.05%)	27.65 (3.66%)	6.00 (7.48%)	11.63 (4.95%)
	Heavy	1.78 (9.35%)	0.25 (9.16%)	0.42 (9.04%)	1.29 (5.63%)	0.31 (9.25%)	29.90 (9.66%)	175.90 (9.38%)	26.00 (9.41%)	5.77 (11.03%)	11.09 (9.35%)
	L.S.D. at 5%	0.05 **	0.02 *	0.01 **	0.02 **	0.01 **	0.33 **	2.24 **	0.92 **	0.16 **	0.30 **
Effect resulted		R	R	I	I	R	R	R	R	R	R

Table No.6: Simple correlation, regression values and linear regression equation when the counts of the mean population density of P. oleae were plotted versus the percentage of reduction in each of mineral contents for mango leaves throughout the two successive seasons (2016/2017 and 2017/2018)

Season / Properties		First season (2016/2017)						Second season (2017/2018)					
		r	b	S.E	T-test value	Y = a ± bx	E.V.%	r	b	S.E	T-test value	Y = a ± bx	E.V.%
Macro-elements	N	0.85**	0.06**	0.01	4.50 **	4.80 + 0.06 x	71.67	0.67 *	0.05 *	0.02	2.47 *	3.03 + 0.05 x	44.61
	P	0.66 *	0.06 *	0.02	2.45 *	4.95 + 0.06 x	42.87	0.86**	0.05**	0.01	4.83 **	4.12 + 0.05 x	73.30
	K	-0.74 *	-0.05 *	0.02	-3.10 *	-5.75 - 0.05 x	54.47	-0.69 *	-0.02 *	0.01	-2.64 *	-6.08 - 0.02 x	47.24
	Ca	-0.75**	-0.06**	0.02	-3.23**	-2.44 -0.06 x	56.54	-0.67 *	-0.03 *	0.01	-2.48 *	-2.46 - 0.03 x	45.31
	Mg	0.89**	0.06**	0.01	5.40**	3.06 + 0.06 x	78.51	0.78**	0.04**	0.01	3.41 **	3.89 + 0.04 x	60.11
Micro-elements	Zn	0.97**	0.05**	0.01	10.92**	5.16 + 0.05 x	93.69	0.86**	0.04**	0.01	4.44 **	5.08 + 0.04 x	74.00
	Fe	0.92**	0.07**	0.01	6.50**	3.08 + 0.07 x	84.12	0.91**	0.05**	0.01	6.38 **	3.14 + 0.05 x	82.54
	Mn	0.82**	0.07**	0.02	4.01**	3.30 + 0.07 x	66.77	0.84**	0.07**	0.02	4.56 **	1.16 + 0.07 x	71.32
	Cu	0.71 *	0.05 *	0.02	2.83 *	6.04 + 0.05 x	50.06	0.78**	0.05**	0.02	3.27 **	5.05 + 0.05 x	61.43
Crude protein		0.85**	0.06**	0.01	4.50**	4.80 + 0.06 x	71.67	0.67 *	0.05 *	0.02	2.47 *	3.03 + 0.05 x	44.61

CONCLUSION

Carried study proved that the population density of *P. oleae* during autumn months was the most serious causing the greatest loss in studied measurements in autumn growth cycle of mango trees during the two seasons as compared with other growth cycles. The loss in the measured parameters was a summation of many factors including the rate of infestation, time of infestation, element contents, essential nutrients and the plant variety.

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CONFLICT OF INTEREST

We declare that we have no conflict of interest.

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