

Effect of Climatic Weather Factors, Physical and Chemical Components of Mango Leaves on the Population Abundance of *Aulacaspis tubercularis* (Newstead)

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Abstract – The present study was carried out throughout two successive years (2017/2018 and 2018/2019) at Esna district, Luxor Governorate, to estimate the effect of climatic weather factors, physical and chemical characteristics of mango leaves on population abundance and percentages of infestation by *Aulacaspis tubercularis* (Newstead) on mango trees. Results indicated that this scale insect species occurred on mango trees all the year round. It had four peaks of population abundance per year. Those were recorded on mid-April, mid-June, beginning of October and mid-November during the first year (2017/2018) and at the beginning of April, beginning of June, mid-September and beginning of November during the second year (2018/2019). Furthermore, percentages of infestation incidence by pest showed, also, four peaks per year. Those recorded in mid-April, beginning of July, beginning of October and mid of November, 2017 and during beginning of April, June, September and beginning of November, 2018. The obtained results cleared that the total population density and percentages of infestation by *A. tubercularis* were higher compared to the subsequent of study. Also, it was generally found that autumn season was more favorable for *A. tubercularis* activity and infestation incidence than the remaining three seasons. Obtained data confirmed that the population abundance and percentages of infestation by *A. tubercularis* were, significantly, affected by the recorded weather factors viz. (daily mean air temperature, mean of relative humidity and mean of dew point), in addition to the morphological and chemical characteristics of mango leaves during the two years of study. Also, the leaf area for mango leaves was the most effective variable for the changes in the insect population and the percentage of moisture in mango leaves was the most affecting factors on the incidence of infestation by the scale insect under the two cumulative years.

Keywords – *Aulacaspis tubercularis*, Population Abundance, Environmental Conditions and Mango Trees.

I. INTRODUCTION

Among several pests, infesting mango trees (*Mangifera indica* L.), the white mango scale insect, *Aulacaspis tubercularis* (Newstead) (Hemiptera: Diaspididae) is one of the most destructive pests of mango trees in Egypt. This pest injures the shoots, twigs, leaves, branches and fruits by sucking the plant sap with the mouth parts, causing thereafter deformations, defoliation, drying up of young twigs, dieback, poor blossoming, death of twig by the action of the toxic saliva and so affecting the commercial value of fruits and their export potential especially to late cultivars where it causes conspicuous pink blemishes around the feeding sites (Nabil *et al.*, 2012 and Sayed, 2012). In nurseries, severe early infestation retards growth. Young trees are particularly vulnerable to excessive leaf loss and death of twigs, during hot dry weather (El-Metwally *et al.*, 2011). The heavily infested premature fruits dropping and the mature fruits became small in size with lacking of juice and were rotted and unfit for commercial use, in addition to reductions in quality and quantity of produced fruits (Bakr *et al.*, 2009 and Abo-Shanab, 2012).

To develop an effective control against *A. tubercularis*, it is essential to know its bio-ecology including

population dynamics under different climatic factors influencing the different phenological stages. Temperature has a direct effect on insect activity and rate of development (**Lamb, 1992**). In addition, such changes in climatic conditions could profoundly affect the population dynamics and the status of insect pests of crops (**Woiwod, 1997**). These effects could either be direct, through the influence on the insects physiology and behavior (**Parmesan, 2007 and Merrill et al. 2008**), or may be mediated by host plants, competitors or natural enemies (**Bale et al. 2002**). **Dent (1991)** clarified that the rate of insect's population abundance at any location and the number of generations are influenced by the environmental factors at that location.

Reactions of mango trees to insect's infestation are variable depending on plant physical properties and chemical components of leaves (**McAuslane, 1996**). There are many factors, which affect the attraction and feeding of the scale (**Dale, 1988**).

The present investigation was carried out in order to estimate the effect of the climatic factors, physical and chemical properties of mango leaves on the population density of *A. tubercularis*.

II. MATERIALS AND METHODS

This study extended for two successive years from March 2017 until February, 2019 in a private mango trees orchard of about five feddans, of 10 years-old at Esna district, Luxor governorate.

Four mango trees, almost uniform and of similar in size, height, vegetative growth and received the same horticultural practices, were selected and labeled. These randomly chosen mango trees did not receive any pesticidal control measures before and during the period of investigation. Regular bimonthly samples of 60 leaves per tree were randomly picked representing the four directions and three levels (heights) of each tree. Leaf samples were randomly picked from the terminal shoots of tree. Every sample was placed in a polyethylene bag and all samples of every date were transferred to the laboratory for inspection using a stereomicroscope. Numbers of alive insects were individually sorted into immature stages (nymphs) and mature stages (adult females + gravid females) were counted on both upper and lower surfaces of mango leaves were counted to represent each inspected date.

The *A. tubercularis* population density was estimated, while its infestation incidence percentages were calculated according to the formula of **Facylate (1971): $A = (n / N) \times 100$** .

Where,

A = Percentage of infestation incidence.

n = No. of infested leaves in which the pest appeared.

N = Total number of picked leaves (Uninfested + Infested) in each inspection date.

Also, the rate monthly variation in the population (R.M.V.P) was calculated according to the formula reported by **Serag-El-Din (1998)**:

$$(R.M.V.P) = \frac{\text{Av. count of insect at a month}}{\text{Av. count given at the preceding month}}$$

Concerning, the effect of the main weather factors on the different stages of *A. tubercularis* population. The

meteorological data viz., mean daily air temperature, mean % of relative humidity and mean of dew point °C, for conditions of Luxor governorate were obtained from the Central Laboratory for Agricultural climate, Agricultural Research Center, Ministry of Agriculture in Giza. The altitude, latitude and longitude of this weather region of Luxor were 99 m, 25.67°N and 32.71°E, respectively.

After inspection, the infested mango leaves were taken for physiological and biochemical measurements to find out the relation between the population density of pest for each inspected date and those measurements. The measurements were carried out as follows:

1. *Physical Measurements:*

1.1. *Leaf Area:*

Was measured by using the following formula of **Ahmed and Morsy (1999)**.

$$\text{Leaf area (cm}^2\text{)} = 0.7 (\text{Length of leaf} \times \text{Width of leaf}) - 1.06.$$

1.2- *Specific Leaf Area (SLA):*

$$\text{SLA (cm}^2\text{/g)} = \frac{\text{Leaf area (cm}^2\text{)}}{\text{Leaf dry weight (g)}}$$

2. *Chemical Measurements:*

The infested of leaf samples were picked and washed with tap water followed by distilled water to remove the dust and any other residues. Samples were, then, dried in an electric oven at 70°C for 48 hours (**According to Chapman and Pratt, 1961**). The fresh and dry weights of leaves were recorded. The dried material was ground by using an electric mill and stored in paper for analysis. Plant materials were digested by using H₂SO₄ as recommended by **Parkinson and Allen (1975)**.

The moisture percentage in leaves was calculated using the following equations:

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

Total nitrogen (N) was determined on dry weight of leaves by micro Kjeldahl methods as recommended by **Bremner (1965)**.

2.2 *Crude Proteins:*

The crude protein was calculated by the formula followed by **Winkleman et al. (1986)**:

$$\text{Crude Protein (\%)} = \text{Nitrogen percent} \times 6.25$$

Averages of *A. tubercularis* stages, climatic factors and morphological and chemical measurements for mango leaves were calculated and shown graphically by Excel sheets. According to the results of the simple correlation, regression coefficient and the partial regression formula which was adopted to find out the simultaneous effects of tested main weather factors on *A. tubercularis*. The partial regression method termed the C-multipliers was adopted according to **Fisher (1950)**. Statistical analysis was carried out with Computer using (**MSTATC Program software, 1980**) to determine the effect of climatic factors, physical and chemical charact-

-eristics on insect population of *A. tubercularis*.

III. RESULTS AND DISCUSSION

The half-monthly counts of *A. tubercularis* stages which infested mango trees at Esna district, Luxor Governorate were recorded through the two successive years (2017/2018 and 2018/2019). Also, half-monthly mean records of climatic weather factors and physical and chemical characteristics for mango leaves throughout the two years of investigation are tabulated in Tables (1 and 2) and Figs. (1 and 2).

The effects of the climatic factors, physical and chemical properties for mango leaves on the seasonal abundance of *A. tubercularis* were estimated on the basis of average number of immature and mature stage counts per leaf in the successive sampling dates.

1. Seasonal Abundance of *A. tubercularis* population on Mango Trees:

1.1. Seasonal Abundance of different Stages of Pest:

A. The first year (2017/2018):

Pre-adult (nymphal) Population:

The nymphal population of *A. tubercularis* started to increase in March and then it highly increased continuously to reach the first peak in the mid-April with mean counts of 47.41 ± 2.44 individuals per leaf under field conditions (23.36°C , temp., 25.14 % R.H. and 6.64°C dew point) and the physical and chemical properties for mango leaf were 54.56 ± 1.43 cm²/g S.L.A., 79.12 ± 2.08 cm² leaf area, $64.63 \pm 1.70\%$ moisture and 7.90 ± 0.21 % protein. Thereafter, the population decreased continuously until reached to the minimum numbers of pest was recorded at the beginning of June. Another increase in population took place in mid-June, where the second peak was 50.93 ± 3.88 individuals/ leaf was recorded at 33.32°C , temp., 17.21% R.H. and 10.86°C dew point. Also, the physical and chemical properties for mango leaf were 59.52 ± 1.28 cm²/g S.L.A., 86.30 ± 1.85 cm² leaf area, $65.87 \pm 1.41\%$ moisture and $8.93 \pm 0.19\%$ protein. Thereafter, the population decreased gradually until beginning of August and then reincreased gradually to reach third peak in the beginning of October, when the population was 84.66 ± 2.97 individuals per leaf at 31.75°C , temp., 25.50 % R.H. and 14.31°C dew point and the physical and chemical properties for mango leaf were 62.30 ± 0.93 cm²/g S.L.A., 90.33 ± 1.35 cm² leaf area, 65.87 ± 0.99 % moisture and 8.93 ± 0.13 % protein. Then, the population decreased in mid-October and then increased gradually to reach the fourth peak in mid-November (78.28 ± 5.93 individuals/ leaf) were recorded under the mean field conditions at 25.00°C , temp., 33.64% R.H. and 11.71°C dew point when the physical and chemical properties for mango leaf were 59.77 ± 0.90 cm²/g S.L.A., 86.67 ± 1.30 cm² leaf area, 63.38 ± 0.95 % moisture and 8.75 ± 0.13 % protein. After that, it decreased continuously until mid-February, 2018 (Table, 1 and illustrated in Fig., 1).

Females' Population (Mature Stages):

The obtained results showed that the adult females increased gradually and successively until to reached the first peak of abundance on mid-April with mean counts of 44.65 ± 1.98 individuals per leaf under field conditions at 23.36°C , temp., 25.14 % R.H. and 6.64°C dew point and the physical and chemical properties of mango leaves were 54.56 ± 1.43 cm²/g S.L.A., 79.12 ± 2.08 cm² leaf area, 64.63 ± 1.70 % moisture and $7.90 \pm$

0.21 % protein. The population, then, decreased gradually in May. After that, it increased again until reached to the second peak in beginning June (41.92 ± 1.70 individuals per leaf) at 30.26°C , temp., 18.29 % R.H. and 9.35°C dew point and the physical and chemical properties for mango leaf were 57.86 ± 1.04 cm^2/g S.L.A., 83.89 ± 1.51 cm^2 leaf area, 64.98 ± 1.17 % moisture and $9.28 \pm 0.17\%$ protein. Then, it gradually decreased until mid-July, then population increased gradually to reach the third peak in mid-September (66.49 ± 1.83 individuals/ leaf) recorded under the mean field conditions at 32.36°C , temp., 23.64% R.H. and 14.07°C dew point and the physical and chemical properties for mango leaf were 60.73 ± 1.33 cm^2/g S.L.A., 91.87 ± 2.02 cm^2 leaf area, 63.50 ± 1.39 % moisture and 8.93 ± 0.20 % protein. Thereafter, it decreased at the beginning of October and reincreased in population to reach the fourth peak (69.67 ± 2.81 individuals per leaf) during mid of October at 30.61°C , temp., 25.64% R.H. and 13.00°C dew point and the physical and chemical properties for mango leaf were 56.88 ± 0.85 cm^2/g S.L.A., 82.48 ± 1.24 cm^2 leaf area, $62.36 \pm 0.93\%$ moisture and $9.01 \pm 0.13\%$ protein. Then, the population decreased continuously until the mid-February, 2018 as presented in Table (1) and illustrated in Fig. (1).

The variance in different stages abundance reflected on the total mixed population of *A. tubercularis* per leaf which had four peaks that were recorded in the mid-April, mid-June, beginning of October and mid-November when the mean population densities were (92.06 ± 3.36 , 88.95 ± 3.26 , 149.22 ± 4.03 and 131.41 ± 6.82 individuals per leaf, respectively; in Table, 1 and illustrated in Fig. 1).

B. The Second Year (2018/2019):

Pre-adults Population (nymphal):

The nymphal population started to increase gradually to reach the first peak during beginning of April with the mean numbers of 42.36 ± 2.57 individuals per leaf under field conditions at 23.53°C , temp., 24.71% R.H. and 7.00°C dew point and the physical and chemical properties of mango leaves were 48.24 ± 1.13 cm^2/g S.L.A., 73.65 ± 1.75 cm^2 leaf area, $60.42 \pm 1.42\%$ moisture and $8.17 \pm 0.19\%$ protein. The population gradually decreased in mid-May. After that, it increased until reached to the second peak in beginning of June, when the population was 45.51 ± 5.01 individuals per leaf under field conditions at 32.24°C , temp., 16.35% R.H. and 9.94°C dew point and the physical and chemical properties for mango leaf were 59.63 ± 1.40 cm^2/g S.L.A., 78.84 ± 1.42 cm^2 leaf area, $63.52 \pm 1.49\%$ moisture and $9.14 \pm 0.16\%$ protein. Then, it gradually decreased until reached in mid of July and the population started increase gradually to reach the third peak in mid of September with the mean numbers of 75.70 ± 5.66 individuals/ leaf were recorded under the mean field conditions at 32.14°C , temp., 27.36% R.H. and 15.57°C dew point and the physical and chemical properties for mango leaf were 59.18 ± 1.39 cm^2/g S.L.A., 89.92 ± 1.97 cm^2 leaf area, $61.98 \pm 1.46\%$ moisture and $8.80 \pm 0.19\%$ protein. Thereafter, it decreased in October and increased again to reach the fourth peak during beginning of November, when the population was 67.95 ± 4.77 individuals per leaf under field conditions at 24.75°C , temp., 35.56% R.H. and 11.94°C dew point and the physical and chemical properties for mango leaf were 54.09 ± 1.27 cm^2/g S.L.A., 81.42 ± 1.22 cm^2 leaf area, $62.33 \pm 1.47\%$ moisture and $8.75 \pm 0.13\%$ protein. After that, it decreased continuously until the mid-February, 2019 as presented in Table (2) and illustrated in Fig. (1).

Females' Population (Mature Stages):

The results showed that the females of pest increased gradually in March and highly increased to reach the fi-

first peak which recorded in the beginning of April with the mean numbers of 41.23 ± 1.98 individuals per leaf under field conditions at 23.53°C , temp., 24.71% R.H. and 7.00°C dew point and the physical and chemical properties for mango leaf were 48.24 ± 1.13 cm^2/g S.L.A., 73.65 ± 1.75 cm^2 leaf area, $60.42 \pm 1.42\%$ moisture and $8.17 \pm 0.19\%$ protein. Then, the population gradually decreased until beginning of May and increased again during mid of May recording the second peak, when the population was 38.38 ± 2.30 individuals per leaf under field conditions at 30.14°C , temp., 16.57% R.H. and 9.14°C dew point and the physical and chemical properties for mango leaf were 47.30 ± 1.11 cm^2/g S.L.A., 70.81 ± 1.22 cm^2 leaf area, $56.88 \pm 1.34\%$ moisture and $8.31 \pm 0.14\%$ protein. After that, it gradually decreased until the beginning of July and the population started increase gradually to reach the third peak in beginning of September with the mean numbers of 57.99 ± 4.05 individuals/leaf were recorded under the mean field conditions at 32.65°C , temp., 25.35% R.H. and 15.41°C dew point and the physical and chemical properties for mango leaf were 61.47 ± 1.45 cm^2/g S.L.A., 88.97 ± 1.33 cm^2 leaf area, $62.84 \pm 1.48\%$ moisture and $9.50 \pm 0.14\%$ protein. Then, it gradually decreased until the mid of October and the population was increased again during beginning of November recording the fourth peak, when the population was 69.31 ± 2.53 individuals per leaf under field conditions at 24.75°C , temp., 35.56% R.H. and 11.94°C dew point and the physical and chemical properties for mango leaf were 54.09 ± 1.27 cm^2/g S.L.A., 81.42 ± 1.22 cm^2 leaf area, $62.33 \pm 1.47\%$ moisture and $8.75 \pm 0.13\%$ protein. Thereafter, it decreased continuously until the mid February, 2019 are represented in Table (2) and illustrated in Fig. (1).

It could be noticed that the seasonal fluctuation of nymphs corresponded with the fluctuation in the total population of *A. tubercularis* was observed. The total population of pest had four peaks of seasonal activity, which was recorded in the beginning of April, beginning of June, mid of September and beginning of November when the population density was 83.59 ± 4.42 , 80.80 ± 4.82 , 130.40 ± 6.11 and 137.26 ± 6.39 individuals per leaf, respectively are shown in Table (2) and illustrated in Fig. (1).

Results showed that the mean total population per leaf through the whole year was 84.48 ± 3.40 and 81.50 ± 2.97 individuals per leaf over first and second years, respectively. The nymphal population were 45.89 ± 1.95 and 43.98 ± 1.64 individuals and the females population were 38.60 ± 1.74 and 37.52 ± 1.59 individuals per leaf were recorded during the first and second years, respectively are represented in Tables (1 and 2). These results were confirmed by the findings of **Shahein et al. (1987)** in Egypt who mentioned that *A. tubercularis* had four overlapping annual generations per year. **Hamdy (2016)** in Shoubra EL-Kheima, Qalubiya, Egypt, reported that the insect had 3-4 generations per year. **Sanad (2017)** in Qalyubiya, also reported that *A. tubercularis* had four generations per year. While, **Radwan (2003)** in Egypt, reported that *A. tubercularis* had three generations on mango trees. Also, **Kawiz (2009)** in Qalubiya, Egypt, reported that, this insect had three peaks on mango which occurred during March, June and November through each of the two years of study, Also, data of the present study, clearly showed that *A. tubercularis* had four overlapping annual generations during the both years of study. **Nabil (2010)** in Sharkia, Egypt, reported that *A. tubercularis* had three overlapping generations on mango trees.

1.2. Percentages of Infestation Incidence throughout the Season:

The percentages of infestation incidence are tabulated in Tables (1 and 2) and Fig. (1). Data showed four peaks of activity during the first year, recorded in the mid-April, beginning of July, beginning of October and mid-November when the percentages of infestation were 87.50 ± 3.15 , 77.50 ± 2.59 , 95.00 ± 2.15 and 100 ± 0.00

%, respectively.

Data of the subsequent year showed, also, four peaks of infestation recorded in the beginning of April, June, September and beginning of November when the percentages of infestation were 82.50 ± 4.64 , $82.50 \pm (4.22 \text{ or } 4.38)$, 100 ± 0.00 and $100 \pm 0.00\%$, respectively.

The obtained results cleared that the total population density of *A. tubercularis* and the percentages of infestation incidence by pest during the first year (2017/2018) were higher than second year (2018/2019). This may due to the influence of environmental factors in this region and the physical and chemical characteristics of mango leaves as recorded in Tables (1 and 2) and illustrated in Fig. (1).

The obtained results in Tables (1 and 2) and Fig. (2) also, showed that the highest population density of nymphs, females and total population of *A. tubercularis* and the percentages of infestation incidence during the two years, were recorded in autumn season (more active), thus due to the environmental conditions which were favorable for the insect activity. While, the least population density of *A. tubercularis* immature stages were recorded in spring and adult females and the total insect population were observed during winter months of the two years, may be due to the unsuitable environmental conditions and cold weather. When crawlers emerged after egg laying, their population decreased during several months due to mortality of nymphs during in the winter months.

These result agreed with the finding of **Kawiz (2009)** in Egypt, and **Bautista et al. (2013)** in Nayarit, Mexico, they reported that autumn was the optimum season for *A. tubercularis* activity. The present data was confirmed also by those of **Shahein et al. (1987)** and **Kawiz (2009)** in Egypt, they stated that the lowest population of *A. tubercularis* occurred in the mid-July. **Labuschagne et al. (1995)** in South Africa, reported that the highest infestation rate of *A. tubercularis* occurred on the shady south. Population peaks of the pest occurred during different periods of the year in the two regions of study. Higher mean population occurred in November and September. The differences between their results and the present may be attributed to the variation between some weather factors or agro-ecosystem.

Results in Tables (1 and 2) and Fig. (3) also, cleared that infested leaves in summer season had bigger specific leaf areas (61.10 ± 0.77 and $57.57 \pm 0.86 \text{ cm}^2/\text{g}$) and higher percentages of moisture content (65.19 ± 0.53 and $63.90 \pm 0.56 \%$), during the two years, respectively than those of the remaining seasons of the year. Also, highest percentages of crude protein in the infested mango leaves occurred in summer season ($8.95 \pm 0.08\%$) in the first year and $9.05 \pm 0.09\%$ in autumn of the second year. As well as, the infested mango leaves in autumn season had bigger leaf areas (87.84 ± 1.15 and $79.75 \pm 2.03 \text{ cm}^2$ during the two years, respectively) than those the other seasons of the year.

2. Rate of Monthly Variation in the Population (R.M.V.P.) of the White Mango Scale Insect, *A. tubercularis*:

The monthly variation rates in the population of different stages and total population of *A. tubercularis* and the percentages of infestation incidence were calculated (Table, 3). The rate of monthly variation in the population is considered an indicator to the favourable month for insect activity expressed as the month of higher increase of this insect population through the year. When R.M.V.P. is > 1 it means more activity, < 1 means less activity and $= 1$ means no change in the insect activity. As recorded in Table (3), the favourable

months of annual increase for pre-adults stage (nymphs) appeared to be in April, July, August, September and November during the first year (2017/2018), when the rates of monthly variation were (2.16, 1.18, 1.02, 1.58 and 1.00, respectively). As well as, the rates of monthly variation (R.M.V.P) for adult females and total population of pest showed that the favourable times for annual increase appeared to be in April, June, August, September and October during the first year when the rates of monthly variation were (1.31, 1.44, 1.66, 1.32 and 1.12) for the adult females and were (1.64, 1.12, 1.26, 1.45 and 1.04, respectively) for the total population.

While, the infestation incidence was higher in months, April, July, August, September, October and November during the first year of study (rates of monthly variation; 1.18, 1.04, 1.07, 1.09, 1.03 and 1.01, respectively). As for the second year (2018/2019), the favourable times of annual increase for pre-adults stage (nymphs), females and total population appeared to be in April, June, August, September, November and February when the rates of monthly variation were (1.37, 1.58, 1.39, 1.36, 1.55 and 2.16) for the immature stages and (1.02, 1.14, 1.99, 1.10, 1.31 and 2.08) for the adult females and were (1.8, 1.35, 1.64, 1.23, 1.42 and 2.13) for the total population of pest, respectively. Also, the infestation incidence increased in April, June, August, September and February during the second year, when the rates of monthly variation were 1.10, 1.16, 1.16, 1.10 and 1.07, respectively (Table, 3).

Generally, it seems that the climatic conditions of autumn and summer months during the two years were more optimum for the insect multiplication and build up. Also, the favourable periods for insect activity varied according to tested stages and the years of the study. These results coincided with those obtained by **Sanad (2017)** in Qalubiya, Egypt. The author reported that the highest population of *A. tubercularis* occurred during autumn season.

*2. Effect of the main Weather Factors, Physical and Chemical Properties for Mango Leaves on the Insect Population and on the Percentages of Infestation Incidence by *A. tubercularis*:*

*2.1. Effect on total Population of *A. tubercularis*:*

A. Effect of daily Mean Temperature:

The results of statistical analysis of simple correlation (Table, 4) showed highly positively significant correlations between the daily mean temperature and total population of *A. tubercularis* (r values; 0.58, and 0.50) for the first year and on two cumulative years altogether, respectively and positively insignificant (r value; 0.40) during the second year. As well as, the calculated regression coefficient (b) for the effect of this factor indicated that every 1°C increase in the daily mean temperature, would increase the population by 2.87, 1.79 and 2.36 individuals per leaf during the two years of study separately and on the two cumulative years altogether, respectively.

The precise effects of temperature on the total insect population are presented in Table (4), those showed significantly negative for the first year (P. reg. value was -8.04) and highly significant negative (P. reg. values were -11.90 and -11.67) for the second year and on the cumulative years. Also, the values of partial correlation were (-0.56, -0.63 and -0.65) and the values of t-test were (-2.66, -3.22 and -5.44) during the first, second years and on the cumulative years, respectively. The obtained results revealed that, daily mean temperature above the optimum range of total population activity during the first year and entirely above the optimum range of total population activity during the second year and on the cumulative years. This climatic factor was responsible for

certain changes in the total insect population by 5.88, 9.53 and 15.39% for the first and second years and on two cumulative years, respectively (Table, 4).

B. Effect of the mean Relative Humidity:

As shown in Table (4), the correlation between relative humidity and the total population was significantly negative (r value; -0.44) for the first year and insignificantly negative (r values were -0.09 and -0.28) during the second year and the two cumulative years, respectively. In the same time, the simple regression coefficient indicated that an increase of 1% in the mean relative humidity, would decrease the population by 1.48, 0.27 and 0.88 individuals per leaf, for the first and second years and during the two cumulative years, respectively.

The real effect of this factor appeared from the partial regression values which showed that the effect of relative humidity was insignificantly negative (P. reg. value; -1.63) for the first year and significantly negative (P. reg. value; -4.02) during the second year and highly significantly negative (P. reg. value; -3.90) for both years altogether. Also, the partial correlation values were negative (P. cor. values were -0.28, -0.54 and -0.57) and t -test values were (-1.15, -2.55 and -4.43) for the 1st, 2nd years and on the cumulative years, respectively. Results revealed that, mean relative humidity was around the optimum range of total population activity during the first year, above the optimum range through the second year and entirely above the optimum range of total population activity during the two cumulative years. This climatic factor was the least effective variable in population changes by 1.09% during the first and was responsible for certain changes in population by 6.00 and 10.21% during the second year and on the two cumulative years, respectively, Table (4).

C. Effect of mean Dew Point:

Data in Table (4) indicated that, the effect of mean dew point on adult females activity was highly significantly positive (0.72, 0.59 and 0.65) during the first and second years and concerning both years, respectively. As well as, the calculated regression coefficient (b) for the effect of this factor indicated that for every 1°C increase, the population would increase by 6.58, 4.53 and 5.45 individuals per leaf during the first and second years and both years, respectively.

The partial regression coefficient values for the effect of mean dew point on the total insect population are shown in Table (4). Data revealed that this factor had highly significant positive relations with the insect's population (P. reg. values were 12.92 and 13.66) during the first year and on the cumulative years, respectively. While, the relation was significantly positive (P. reg. value; 12.11) through the second year. The values of the partial correlation were (0.68, 0.55 and 0.69), also (t -test) values were (3.72, 2.66 and 6.01) during the two study years separately and on the cumulative basis, respectively. The obtained results revealed that, the mean dew point was entirely under the optimum range of total population activity during the first year and on both years and under the optimum range through the second year, and it was responsible for the certain changes in the total population by 11.43, 6.52 and 18.78 % during the three research periods, respectively in (Table, 4).

D. Effect of Specific Mango Leaf Area on total Population:

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. As tabulated in Table (4), the correlation coefficient (r) between the specific mango leaf area and total population of *A. tubercularis* was

insignificantly positive (0.36 and 0.25) in the first and second years, respectively and significantly positive (0.30) through the two years altogether. The unit effect regression coefficient (b) indicated that one cm^2/g increase in the specific mango leaf area, would increase the population by 2.47, 1.16 and 1.64 individuals per leaf during the both the study years separately and on the cumulative years basis, respectively.

The partial regression values emphasized a highly significant negative effect (P. reg. values; -5.54) for the first year and significant negative relations (P. reg. values; -2.01 and -2.29) during the second year and on both years, respectively. Also, the partial correlation values were (-0.72, -0.54 and -0.48) and the values of "t-test" were (-4.10, -2.55 and -3.47) during the first, second years and on the cumulative years, respectively. The obtained results indicated that specific leaf area for mango leaves was the most effective variable for the changes in the total insect population by 13.92% during the first year and was responsible for the certain changes in the total population by 5.92 and 6.23% during the second year and through the two cumulative years, respectively (Table, 4).

E. Effect of Mango Leaf Area on Total Population:

Results in Table (4) show the effect of the mango leaf area on total population of *A. tubercularis*. The correlation coefficient (r) was highly significantly positive (r values were 0.74, 0.73 and 0.69) for the first and second years and on the cumulative years, respectively. The calculated regression coefficient (b) for the effect of this factor indicated that for every one cm^2 increase in the leaf area for mango, the population of *A. tubercularis* would increase by 3.97, 3.13 and 3.02 individuals per leaf during the both the study years separately and on the cumulative years basis, respectively.

The exactly relationship between the mango leaf area and total population of pest was determined by the partial regression values (Table, 4), which were highly significantly positive (P. reg. values were 5.11, 3.51 and 3.68) for the first, second years and on the cumulative years, respectively. An increase by one cm^2 in mango leaf area, would increase the population by 5.11, 3.51 and 3.68 individuals per leaf during the first and second years and the two cumulative years, respectively.

The values of the partial correlation were (0.71, 0.76 and 0.72), also (t-test) values were (3.98, 4.64 and 6.51) during the both the study years separately and on the cumulative basis, respectively (Table, 4). Also, the leaf area for mango was the most effective variable for the changes in the total population of *A. tubercularis* by 13.14, 19.66 and 22.01% during the first and second years and the two cumulative years, respectively in Table (4).

F. Effect of Moisture in Mango Leaves on total Population:

Data in Table (4) showed that, the effect of % moisture in mango leaves on total population activity was highly significantly positive (0.57 and 0.49) during the first year and on the cumulative years, respectively and insignificantly positive relation (r value was 0.40) during the second year. In the same time, the simple regression coefficient indicated that an increase by 1% in the percentage of moisture in mango leaves, would increase the population by 5.87, 3.44 and 4.47 individuals per leaf, for the three periods of study, respectively.

The recorded partial regression values emphasized significantly positive effect of the percentage of moisture in mango leaves on the activity of the total population in the first year (P. reg. values; 5.12) and insignificantly

positive relations (P. reg. values; 2.31 and 2.23) during the second year and on the two cumulative years, respectively. Also, the partial correlation values were (0.55, 0.32 and 0.30) and the values of "t-test " were 2.62, 1.36 and 2.02) during the three research periods, respectively in (Table, 4). The obtained results indicated that percentage of moisture in mango leaves was responsible for certain changes in the total population of insect by 5.68, 1.70 and 2.02% during the first, second years and through two cumulative years, respectively in Table (4).

G. *Effect of Protein Content in Mango Leaves:*

Data obtained are presented in Table (4), showed that the percentage of protein in mango leaves had insignificant positive effect on total population activity in the first year, since the correlation coefficient was (0.39). While, it had highly significantly positive effect during the second year and on the two cumulative years (0.63 and 0.50), respectively. The unit effect (regression coefficient) indicated that an increase of 1% in the percentage of protein in mango leaves, would increase the population by 29.24, 31.10 and 30.49 individuals per leaf, for the three periods of study, respectively.

The real effect of the percentage of protein in mango leaves was clear from the partial regression (P. reg.) values in Table (4). Data showed that it had significant negative effect (P. reg. value; -24.19) in the first year, significant positive relation (P. reg. value; 19.50) in the second year and insignificant positive effect (P. reg. value; 5.87) for the two cumulative years. The partial correlation values were (-0.49, 0.57 and 0.14) and the values of "t-test " were (-2.26, 2.76 and 0.93) during the first and second years and during the two cumulative years respectively.

The obtained results indicated that the percentage of protein in mango leaves was responsible for certain changes in the total population of insect by 4.25 and 7.05% during the first and second years, respectively, while this factor was the least effective in population changes by 0.44% when concerning the two years altogether.

H. *The Combined effect of the Tested Factors on the Total Population of A. tubercularis:*

As shown in Table (4), the combined effect of these tested factors on the *A. tubercularis* total population was highly significant where the "F" values were 15.00, 13.21 and 21.75 during the first, second years and during the two cumulative years, respectively. The amounts of variability were 86.78, 85.26 and 79.20% for the two years separately and during the two cumulative years altogether, respectively. The remaining unexplained variances are assumed to be due to the influences of other undetermined and unconsidered factors that were not included in this study in addition to the experimental error. Similar conclusion was obtained by **Bakr et al. (2009)** who mentioned that there were negative correlation between the fluctuations of *A. tubercularis* population and temperature degrees. **El-Metwally et al. (2011)** in Damietta, Egypt, reported that the variables of temperature and R.H.% had slight effect on *A. tubercularis*, but didn't reach the significant level except for the effect of maximum R.H % which was highly significant and minimum R.H % which was significant. **Nabil et al. (2012)** stated that the combined effect of means of air temperature (°C), relative humidity (RH%) and Light intensity (Lux) on the total number of alive *A. tubercularis* stages by 77.66 and 39.44% during the first and second years of study.

2.2. *Effect on the percentages of Infestation Incidence:*

A. *Effect of Daily Mean Temperature:*

Results presented in Table (5) showed that the simple correlation (r) between the daily mean temperature and the infestation incidence was insignificantly positive (0.21) for the first year and highly significantly positive (0.73 and 0.51) through the second year and the two years altogether. As well as, the calculated regression coefficient (b) for the effect of this factor indicated that every 1°C increase in the daily mean temperature, would increase the percentage of infestation incidence by 0.29, 1.79 and 1.01% during either of the three periods (Table, 5).

The precise effect of this factor on the infestation incidence (Table, 5) showed that it had highly significantly negative effect (P. reg. value; -4.56) for the first year and insignificantly negative relation (P. reg. value; -4.28) for the second year. While, it was significantly negative (P. reg. value; -2.92) for the two cumulative years. Also, the values of partial correlation were (-0.72, -0.41 and -0.34, respectively), and the t-test values were (-4.12, -1.79 and -2.30, respectively), Table (5).

The obtained results revealed that, daily mean temperature entirely above the optimum range of *A. tubercularis* infestation during the first year and around the optimum range during the second year. While, it was above the optimum range during the two cumulative years. This climatic factor was responsible for certain changes in the percentages of infestation incidence by 24.70, 4.08 and 5.53 % during the three periods of study, respectively (Table, 5).

B. Effect of the Mean Relative Humidity:

Data in Table (5), showed that the mean relative humidity had insignificant negative effect on infestation incidence, since the correlation coefficient was ($r = -0.11$) during the first year, while, relations were significantly negative during the second year and the two cumulative years ($r = -0.42$ and -0.30 , respectively). The unit effect (regression coefficient) indicated that an 1% increase in the mean relative humidity, would decrease the percentage of infestation incidence by 0.10, 0.67 and 0.39% during the three periods of study, respectively (Table, 5).

The real effect of R.H. is clear from the partial regression (P. reg.) values in Table (5). Data showed that it was significantly negative (-1.23) during the first year and insignificantly negative (-1.79 and -0.83) during the second year and the two cumulative years, respectively. Also, the values of partial correlation were (-0.45, -0.44 and -0.25) and the values of t-test were (-2.37, -1.75 and -1.60) during the three periods of study, respectively (Table, 5). The obtained results revealed that, mean relative humidity was above the optimum range of infestation incidence by pest for the first year and around the optimum range during the second year and the two cumulative years and that this climatic factor was responsible for certain changes in the infestation incidence by 8.16, 3.93 and 2.66% during the first and second years and through the two cumulative years, respectively (Table, 5).

C. Effect of Mean Dew Point:

Regarding the data in Table (5), the effect of mean dew point on infestation incidence by *A. tubercularis* was significantly positive (0.46) during the first year and highly significantly positive (0.75 and 0.61) through the second year and the two cumulative years, respectively. As well as, the calculated regression coefficient (b) for the effect of this factor indicated that every 1°C increase in the daily mean dew point, would increase the percentage of infestation incidence by 1.16, 3.16 and 2.14% during the three periods of study, respectively (Tab-

-le, 5).

The partial regression values (Table, 5) emphasized highly significantly positive relation (P. reg. values; 6.01 and +3.65) during the first year and both cumulative years, respectively and insignificant positive relation (5.43) through the second year. The values of the partial correlation were (0.76, 0.42 and 0.39), also (t- test) values were (4.73, 1.84 and 2.72) during the three periods of study, respectively (Table, 5). The obtained results revealed that, mean dew point was entirely under the optimum range of infestation incidence by pest throughout the first year and on the two cumulative years, while, it was within the optimum range for the second year. This climatic factor was the most effective variable for the changes in the infestation incidence by 32.43, 4.34 and 7.71% during the three periods of study, respectively (Table, 5).

D. *Effect of Specific Mango Leaf Area:*

The effect of the specific mango leaf area on infestation incidence by *A. tubercularis* (Table, 5). The correlation coefficient (r) was insignificantly positive (r values; 0.29, 0.20 and 0.25) for the first and second years and the two cumulative years. The calculated regression coefficient (b) for the effect of this factor indicated that for every more one cm²/g in the specific leaf area of mango leaves, would increase the percentage of infestation incidence by 0.55, 0.51 and 0.57%, during either of the three periods, respectively.

The partial regression values (Table, 5), were significantly negative (P. reg. values; -1.06 and -0.88) for the first year and the two cumulative years, respectively and insignificantly negative (-0.76) through the second year. Also, the partial correlation values were negative (-0.47, -0.34 and -0.34), also (t-test) values were (-2.14, -1.47 and -2.27) during the three periods of study, respectively (Table, 5). Also, the specific leaf area for mango leaves was responsible for certain changes in the infestation incidence by 6.65, 2.77 and 5.35% during the first and second years and the two cumulative years, respectively (Table, 5).

E. *Effect of Mango Leaf Area:*

According to Table (5), the correlation coefficient (r) between the specific leaf area for mango leaves and infestation incidence was significantly positive (0.47) in the first year and highly significant positive (0.55 and 0.51) through the second year and the two cumulative years, respectively. The unit effect (regression coefficient) indicated that an increase of one cm² in the mango leaf area, would increase the percentage of infestation incidence by 0.70, 1.30 and 0.94% for the first and second years and the two cumulative years, respectively.

The partial regression values emphasized insignificant positive effects (P. reg. values; 0.88 and 0.77) in the two years, separately and significantly positive (0.79) for the two cumulative years. Also, the partial correlation values were positive (0.42, 0.37 and 0.35, respectively) and the "t-test" values were (1.87, 1.58 and 2.38, respectively). The obtained results indicated that mango leaf areas were responsible for certain changes in the infestation incidence of insect by 5.09, 3.17 and 5.89% during the three periods of study, respectively (Table, 5).

F. *Effect of Moisture in Mango Leaves:*

The moisture content in mango leaves had insignificantly positive effect on infestation incidence (correlation coefficient; r = 0.36) for the first year and highly significantly positive relations (0.74 and 0.60) during the second year and the two cumulative years, respectively. The unit effect (regression coefficient) indicated that an

increase of 1% in the percentage of moisture in mango leaves, would increase the percentage of infestation incidence by 1.03, 3.51 and 2.30 % for the first and second years and during the two cumulative years respectively.

The real effect of the moisture content in mango leaves was clear from the partial regression (P. reg.) values (Table, 5). Data showed insignificantly positive effect (1.25) in the first year, significantly positive relation (2.39) in the second year and highly significantly positive effect (2.23) during the two cumulative years. Also, the partial correlation values were positive (0.40, 0.48 and 0.47) and the values of "t-test" were (1.75, 2.18 and 3.33, respectively). The obtained results indicated that percentage of moisture in mango leaves was the least effective variable in the percentages of infestation incidence by 4.44, 6.11 and 11.58% during the first and second years and the two cumulative years, respectively.

G. Effect of Protein in Mango Leaves:

The effect of % protein in mango leaves on the percentages of infestation incidence by pest was insignificantly positive (0.13) during the first year and highly significantly positive relations (0.62 and 0.46) through the second year and on the two cumulative years, respectively. In the same time, the simple regression coefficient indicated that an increase of 1% in the percentage of protein in mango leaves, would increase the percentages of infestation incidence by 2.65, 16.78 and 11.67%, respectively.

The partial regression (P. reg.) values indicated that the effect of protein % in mango leaves was insignificantly negative on the percentages of infestation incidence (P. reg. value; -7.18) in the first year and insignificantly positive (4.76 and 2.02) during the second year and in the two cumulative years, respectively. Also, the partial correlation were (-0.42, +0.25 and +0.09) and the values of "t-test " were (-1.83, +1.04 and +0.54) during the first and second years and on the cumulative years, respectively. The obtained results indicated that protein content in mango leaves was the least effective variable in the percentages of infestation incidence by 4.90, 1.39 and 0.31% during the three periods of study, respectively (Table, 5).

H. The Combined Effect of all Tested Factors on the Percentages of Infestation Incidence:

The results showed that the combined effect of these tested factors on the infestation incidence by pest was highly significant where the "F" values were 7.56, 8.84 and 7.94 during the first, second years and on the cumulative years, respectively (Table, 5). The multiple regression analysis revealed that the tested studied variables together were responsible for the changes in the infestation incidence by pest. The percentages of explained variance (E.V. %) were 76.79, 79.45 and 58.16 %, respectively for the two years separately and during the two cumulative years altogether. The remaining unexplained variances are assumed to be due to the influences of other unconsidered and undetermined factors that were not included in this study in addition to the experimental error.

3.3. Prediction of different A. tubercularis Alive Stages of and the Percentages of Infestation Incidence:

Furthermore, the climatic factors, physical characteristics and chemical components for mango leaves, that could be used to predict total population of pest and the percentage of infestation incidence by *A. tubercularis*, were the daily mean air temperature (x_1), relative humidity (x_2), dew point (x_3), specific leaf area (x_4), leaf area

(x_5), moisture (x_6) and protein (x_7). Prediction equations were used according to the mentioned statistical analysis on the basis of the two cumulative years altogether in Tables (4 and 5) and presented as follow:

$Y = 15.52 - 0.65 x_1^{**} - 0.57 x_2^{**} + 0.69 x_3^{**} - 0.48 x_4^* + 0.72 x_5^{**} + 0.30 x_6 + 0.14 x_7$ E.V. = 79.20 % for total population

$Y = -22.42 - 0.34 x_1^* - 0.24 x_2 + 0.39 x_3^{**} - 0.34 x_4^* + 0.35 x_5^* + 0.47 x_6^{**} + 0.09 x_7$ E.V. = 58.16 % for infestation incidence

Where is, Y = Prediction value. E.V. % = Explained variance * Significant at $P \leq 0.05$ ** Highly significant at $P \leq 0.01$

The aforementioned results on the effect of tested climatic factors, physical characteristics and chemical components for mango leaves on the insect population and on the percentages of infestation incidence by *A. tubercularis* during the two successive years emphasized that the effect of these factors varied from year to another. Also, the leaf area for mango leaves was the most effective variables for the changes in the insect population and the percentage of moisture in mango leaves was the most affecting factors on the percentages of infestation incidence by pest during the two cumulative years.

Table 1. Half-monthly mean counts of different stages of *A. tubercularis* and the percentages of infestation incidences on mango trees, with climatic factors, physical and chemical measurements at Esna district, Luxor Governorate during the first year of (2017/2018).

Season	Date of inspection		Mean number of individuals per leaf \pm S.E.			Infestation incidence (%)	Climatic factors			Physical and chemical properties			
			Immature stages (Pre-adults)	Mature stage (Adult females)	Total		Mean temp. $^{\circ}$ C	%R.H.	Dew point $^{\circ}$ C	S.L.A. (cm^2/g)	Leaf area (cm^2)	Moisture (%)	Protein (%)
Spring	March, 2017	1	13.78 \pm 1.48	26.84 \pm 1.08	40.63 \pm 2.03	67.50 \pm 3.50	18.96	41.36	4.64	57.65 \pm 1.36	74.95 \pm 1.76	59.88 \pm 1.41	7.76 \pm 0.18
		15	26.75 \pm 2.15	39.90 \pm 1.72	66.65 \pm 3.57	77.50 \pm 4.00	19.32	30.07	4.36	58.32 \pm 1.41	77.98 \pm 1.88	63.55 \pm 1.53	7.81 \pm 0.19
	April	1	40.31 \pm 3.13	43.03 \pm 2.02	83.35 \pm 3.53	82.92 \pm 3.43	22.06	32.41	5.24	54.31 \pm 1.29	78.75 \pm 1.87	62.00 \pm 1.47	8.29 \pm 0.20
		15	47.41 \pm 2.44	44.65 \pm 1.98	92.06 \pm 3.36	87.50 \pm 3.15	23.36	25.14	6.64	54.56 \pm 1.43	79.12 \pm 2.08	64.63 \pm 1.70	7.90 \pm 0.21
	May	1	45.62 \pm 2.39	33.06 \pm 1.38	78.68 \pm 3.48	80.00 \pm 3.66	26.09	19.19	6.38	55.41 \pm 1.22	80.35 \pm 1.77	60.70 \pm 1.34	8.02 \pm 0.18
		15	36.47 \pm 2.06	22.48 \pm 0.97	58.95 \pm 2.91	75.00 \pm 3.60	28.18	18.07	7.43	48.62 \pm 0.84	75.36 \pm 1.30	58.60 \pm 1.01	8.44 \pm 0.15
Average			35.06 \pm 2.57	34.99 \pm 1.81	70.05 \pm 3.73	78.40 \pm 1.84	23.00	27.71	5.78	54.81 \pm 0.80	77.75 \pm 0.77	61.56 \pm 0.67	8.04 \pm 0.08
Summer	June	1	23.59 \pm 1.60	41.92 \pm 1.70	65.51 \pm 1.74	72.50 \pm 1.73	30.26	18.29	9.35	57.86 \pm 1.04	83.89 \pm 1.51	64.98 \pm 1.17	9.28 \pm 0.17
		15	50.93 \pm 3.88	38.02 \pm 1.61	88.95 \pm 3.26	75.00 \pm 2.97	33.32	17.21	10.86	59.52 \pm 1.28	86.30 \pm 1.85	65.87 \pm 1.41	8.93 \pm 0.19
	July	1	44.09 \pm 2.60	34.67 \pm 1.40	78.76 \pm 2.53	77.50 \pm 2.59	31.88	19.56	11.63	67.04 \pm 1.44	88.83 \pm 1.91	66.23 \pm 1.42	8.75 \pm 0.19
		15	43.83 \pm 3.11	20.12 \pm 0.92	63.94 \pm 3.76	76.25 \pm 3.36	33.50	19.79	12.79	59.75 \pm 1.28	79.62 \pm 1.71	66.04 \pm 1.42	8.78 \pm 0.19
	August	1	39.92 \pm 1.81	36.59 \pm 1.48	76.51 \pm 2.13	80.00 \pm 2.04	35.00	20.06	13.65	62.26 \pm 1.07	87.17 \pm 1.50	64.65 \pm 1.12	9.01 \pm 0.16
		15	49.36 \pm 3.51	54.46 \pm 2.24	103.82 \pm 5.72	85.00 \pm 4.56	34.30	20.86	14.07	60.18 \pm 1.50	91.40 \pm 2.28	63.40 \pm 1.58	8.93 \pm 0.22
Average			41.95 \pm 2.14	37.63 \pm 2.20	79.58 \pm 3.12	77.71 \pm 1.37	33.04	19.30	12.06	61.10 \pm 0.77	86.20 \pm 1.02	65.19 \pm 0.53	8.95 \pm 0.08
Autumn	September	1	67.27 \pm 3.52	53.71 \pm 1.05	120.98 \pm 3.78	87.50 \pm 2.59	34.76	21.71	14.88	66.89 \pm 1.00	94.66 \pm 1.42	65.87 \pm 0.99	8.39 \pm 0.13
		15	74.15 \pm 6.05	66.49 \pm 1.83	140.64 \pm 4.95	92.50 \pm 3.08	32.36	23.64	14.07	60.73 \pm 1.33	91.87 \pm 2.02	63.50 \pm 1.39	8.93 \pm 0.20
	October	1	84.66 \pm 2.97	64.56 \pm 2.61	149.22 \pm 4.03	95.00 \pm 2.15	31.75	25.50	14.31	62.30 \pm 0.93	90.33 \pm 1.35	65.87 \pm 0.99	8.93 \pm 0.13
		15	52.99 \pm 3.02	69.67 \pm 2.81	122.66 \pm 3.16	90.00 \pm 2.64	30.61	25.64	13.00	56.88 \pm 0.85	82.48 \pm 1.24	62.36 \pm 0.93	9.01 \pm 0.13
	November	1	59.80 \pm 5.74	54.85 \pm 0.64	114.66 \pm 5.74	87.50 \pm 4.11	29.35	26.94	12.41	50.65 \pm 0.76	81.03 \pm 1.21	59.04 \pm 0.88	8.88 \pm 0.13
		15	78.28 \pm 5.93	53.13 \pm 1.29	131.41 \pm 6.82	100.00 \pm 0.00	25.00	33.64	11.71	59.77 \pm 0.91	86.67 \pm 1.30	63.38 \pm 0.95	8.75 \pm 0.13
Average			69.52 \pm 2.83	60.40 \pm 1.55	129.93 \pm 3.06	92.08 \pm 1.35	30.64	26.18	13.40	59.54 \pm 1.10	87.84 \pm 1.15	63.34 \pm 0.61	8.82 \pm 0.07
Winter	December	1	60.87 \pm 3.21	35.30 \pm 1.46	96.17 \pm 2.95	94.17 \pm 1.98	23.91	35.88	10.69	67.56 \pm 1.01	84.45 \pm 1.27	62.66 \pm 0.94	7.90 \pm 0.12
		15	51.73 \pm 2.72	35.58 \pm 1.45	87.30 \pm 2.54	90.00 \pm 2.45	18.11	38.50	6.79	55.42 \pm 0.83	76.18 \pm 1.14	62.53 \pm 0.94	8.25 \pm 0.12
	January, 2018	1	35.16 \pm 2.38	20.66 \pm 0.86	55.82 \pm 1.80	85.00 \pm 3.04	17.09	39.82	5.06	55.29 \pm 1.34	74.64 \pm 1.80	57.87 \pm 1.40	8.25 \pm 0.20
		15	30.20 \pm 1.61	16.11 \pm 0.74	46.31 \pm 1.63	80.00 \pm 2.45	14.71	48.29	6.21	54.87 \pm 0.82	74.07 \pm 1.11	57.63 \pm 0.86	8.34 \pm 0.12
	February	1	26.74 \pm 1.02	11.96 \pm 0.86	38.70 \pm 1.10	72.50 \pm 2.10	15.76	45.88	5.82	58.47 \pm 0.87	78.93 \pm 1.17	57.39 \pm 0.85	8.65 \pm 0.13
		15	17.38 \pm 0.64	8.58 \pm 0.52	25.96 \pm 0.73	62.50 \pm 1.73	19.57	44.36	7.36	53.09 \pm 0.78	74.33 \pm 1.09	55.30 \pm 0.81	8.29 \pm 0.12
Average			37.01 \pm 3.20	21.36 \pm 2.25	58.38 \pm 5.33	80.69 \pm 2.38	18.19	42.12	6.99	57.45 \pm 1.06	77.10 \pm 0.90	58.90 \pm 0.67	8.28 \pm 0.07
Total			1101.29	926.33	2027.62								
General average			45.89 \pm 1.95	38.60 \pm 1.74	84.48 \pm 3.40	82.22 \pm 1.06	26.22	28.83	9.56	58.23 \pm 0.52	82.22 \pm 0.69	62.25 \pm 0.39	8.52 \pm 0.05
%			54.31	45.69	100.00								

Table 2. Half-monthly mean counts of different stages of *A. tubercularis* and the percentages of infestation incidences on mango trees, with climatic factors, physical and chemical measurements at Esna district, Luxor Governorate during the second year of (2018/2019).

Season	Date of inspection		Mean number of individuals per leaf ± S.E.			Infestation incidence (%)	Climatic factors			Physical and chemical properties			
			Immature stages (Pre-adults)	Mature stage (Adult females)	Total		Mean temp. °C	%R.H.	Dew point °C	S.L.A. (cm ² /g)	Leaf area (cm ²)	Moisture (%)	Protein (%)
Spring	March, 2018	1	23.38 ± 0.84	32.63 ± 2.61	56.00 ± 3.05	67.50 ± 3.63	19.39	28.86	4.86	57.51 ± 1.35	73.27 ± 1.27	58.20 ± 1.37	7.64 ± 0.18
		15	35.09 ± 2.38	37.66 ± 1.99	72.75 ± 4.04	80.00 ± 4.46	22.29	24.93	6.14	55.54 ± 1.31	72.77 ± 1.76	62.03 ± 1.46	7.69 ± 0.19
	April	1	42.36 ± 2.57	41.23 ± 1.98	83.59 ± 4.42	82.50 ± 4.64	23.53	24.71	7.00	48.24 ± 1.13	73.65 ± 1.75	60.42 ± 1.42	8.17 ± 0.19
		15	37.96 ± 1.92	30.51 ± 3.07	68.47 ± 3.77	80.00 ± 4.46	24.46	21.93	6.71	56.21 ± 1.32	74.35 ± 1.95	63.16 ± 1.49	7.90 ± 0.21
	May	1	32.62 ± 1.77	20.63 ± 1.04	53.25 ± 2.77	70.00 ± 3.60	25.34	19.94	6.94	59.27 ± 1.39	75.51 ± 1.67	58.20 ± 1.37	7.41 ± 0.16
		15	21.08 ± 1.16	38.38 ± 2.30	59.46 ± 3.30	72.50 ± 3.88	30.14	16.57	9.14	47.30 ± 1.11	70.81 ± 1.22	56.88 ± 1.34	8.31 ± 0.14
Average			32.08 ± 1.72	33.51 ± 1.63	65.59 ± 2.55	75.42 ± 1.90	24.19	22.82	6.80	54.01 ± 1.06	73.39 ± 0.68	59.82 ± 0.69	7.85 ± 0.09
Summer	June	1	45.51 ± 3.01	35.29 ± 3.53	80.80 ± 4.82	82.50 ± 4.38	32.24	16.35	9.94	59.63 ± 1.40	84.84 ± 1.42	63.52 ± 1.49	9.14 ± 0.16
		15	39.41 ± 1.41	32.18 ± 2.13	71.58 ± 3.77	82.50 ± 4.22	34.32	15.64	11.21	60.02 ± 1.41	81.42 ± 1.75	63.08 ± 1.48	8.90 ± 0.19
	July	1	39.19 ± 1.11	18.48 ± 1.86	57.67 ± 2.71	77.50 ± 3.70	32.53	21.88	13.31	54.57 ± 1.28	76.15 ± 1.63	64.62 ± 1.52	8.80 ± 0.19
		15	35.69 ± 0.91	33.17 ± 3.33	68.86 ± 3.70	80.00 ± 4.51	32.64	26.21	15.57	52.27 ± 1.23	72.10 ± 1.55	64.62 ± 1.97	8.65 ± 0.19
	August	1	44.14 ± 3.10	50.03 ± 4.92	94.17 ± 5.39	85.00 ± 4.36	32.26	23.41	14.06	56.79 ± 1.34	81.92 ± 1.41	63.17 ± 1.49	8.87 ± 0.15
		15	60.13 ± 2.95	52.66 ± 5.12	112.79 ± 5.65	97.50 ± 2.50	32.11	22.36	14.00	62.13 ± 1.46	87.63 ± 2.18	64.40 ± 1.51	8.80 ± 0.22
Average			44.01 ± 2.02	36.97 ± 2.75	80.98 ± 4.10	84.17 ± 1.97	32.68	20.98	13.02	57.57 ± 0.86	79.68 ± 1.18	63.90 ± 0.56	8.86 ± 0.07
Autumn	September	1	66.28 ± 5.28	57.99 ± 4.05	124.27 ± 6.59	100.00 ± 0.00	32.65	25.35	15.41	61.47 ± 1.45	88.97 ± 1.33	62.84 ± 1.55	9.50 ± 0.14
		15	75.70 ± 5.66	54.70 ± 2.50	130.40 ± 6.11	100.00 ± 0.00	32.14	27.36	15.57	59.18 ± 1.39	89.92 ± 1.97	61.98 ± 1.46	8.80 ± 0.19
	October	1	47.36 ± 3.09	50.48 ± 2.05	97.84 ± 5.07	97.50 ± 0.83	31.31	28.25	14.88	53.93 ± 1.27	74.77 ± 1.12	64.44 ± 1.52	8.80 ± 0.13
		15	37.48 ± 1.31	43.88 ± 4.32	81.36 ± 4.59	95.00 ± 0.96	26.61	30.43	11.93	42.40 ± 1.00	61.95 ± 0.93	60.79 ± 1.43	8.87 ± 0.13
	November	1	67.95 ± 4.77	69.31 ± 2.53	137.26 ± 6.39	100.00 ± 0.00	24.75	35.56	11.94	54.09 ± 1.27	81.42 ± 1.22	62.33 ± 1.47	8.75 ± 0.13
		15	63.43 ± 2.99	54.26 ± 3.24	117.69 ± 5.65	90.00 ± 3.85	22.93	39.36	11.57	67.80 ± 1.59	81.45 ± 1.22	61.86 ± 1.45	9.57 ± 0.14
Average			59.70 ± 3.11	55.10 ± 1.99	114.80 ± 4.55	97.08 ± 0.97	28.40	31.05	13.55	56.48 ± 1.71	79.75 ± 2.03	62.37 ± 0.58	9.05 ± 0.09
Winter	December	1	60.16 ± 3.69	45.85 ± 2.00	106.01 ± 5.49	80.00 ± 4.14	21.22	45.06	11.69	55.04 ± 1.29	79.37 ± 1.19	58.21 ± 1.37	8.13 ± 0.12
		15	29.70 ± 1.64	19.02 ± 1.87	48.72 ± 3.05	57.50 ± 3.76	18.29	45.79	9.29	63.39 ± 1.49	74.17 ± 1.11	60.97 ± 1.43	8.00 ± 0.12
	January, 2019	1	25.42 ± 1.56	14.11 ± 1.42	39.53 ± 2.76	55.00 ± 3.91	14.94	46.18	5.88	52.26 ± 1.23	68.37 ± 1.65	56.11 ± 1.32	7.78 ± 0.19
		15	22.41 ± 2.06	12.53 ± 1.26	34.95 ± 2.68	50.00 ± 4.30	16.18	49.07	7.36	53.52 ± 1.26	69.60 ± 1.04	55.86 ± 1.31	8.21 ± 0.12
	February	1	49.88 ± 3.05	26.71 ± 2.69	76.59 ± 4.49	55.00 ± 3.40	17.12	32.35	4.41	55.43 ± 1.30	74.17 ± 1.10	55.61 ± 1.31	8.52 ± 0.13
		15	53.26 ± 2.49	28.81 ± 2.84	82.07 ± 4.62	57.50 ± 2.85	17.07	35.36	5.29	43.44 ± 1.02	74.33 ± 1.09	53.44 ± 1.26	8.17 ± 0.12
Average			40.14 ± 3.21	24.50 ± 2.47	64.64 ± 5.52	59.17 ± 2.43	17.47	42.30	7.32	53.85 ± 1.31	73.33 ± 0.87	56.70 ± 0.69	8.14 ± 0.07
Total			1055.58	900.49	1956.07								
General average			43.98 ± 1.64	37.52 ± 1.59	81.50 ± 2.97	78.96 ± 1.69	25.69	29.29	10.17	55.48 ± 0.65	76.54 ± 0.72	60.70 ± 0.42	8.47 ± 0.06
%			53.96	46.04	100.00								

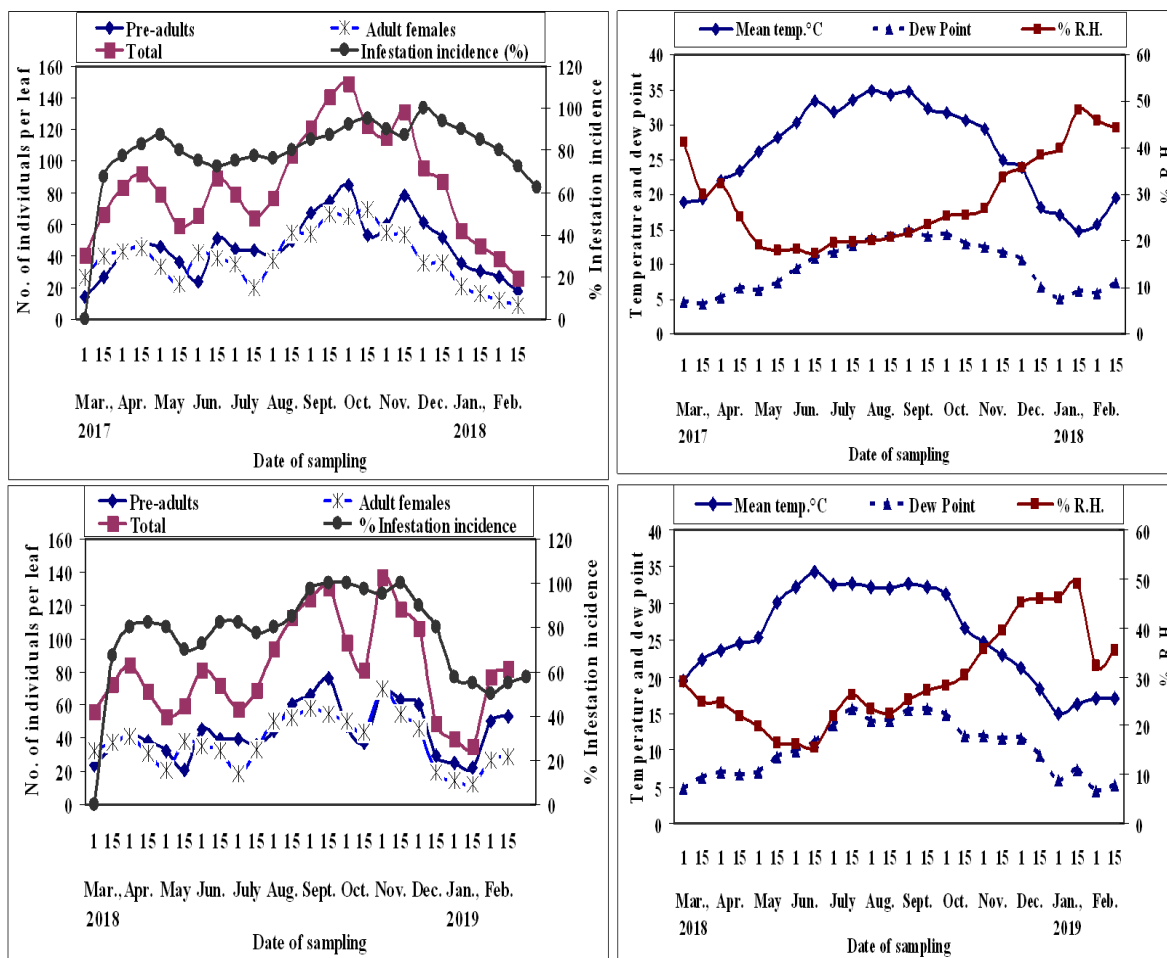


Fig. 1. Half-monthly mean numbers of different stages of *A. tubercularis* and the percentages of infestation incidences on mango trees, with climatic factors at Esna district, Luxor Governorate during the two successive years (2017/2018 and 2018/2019).

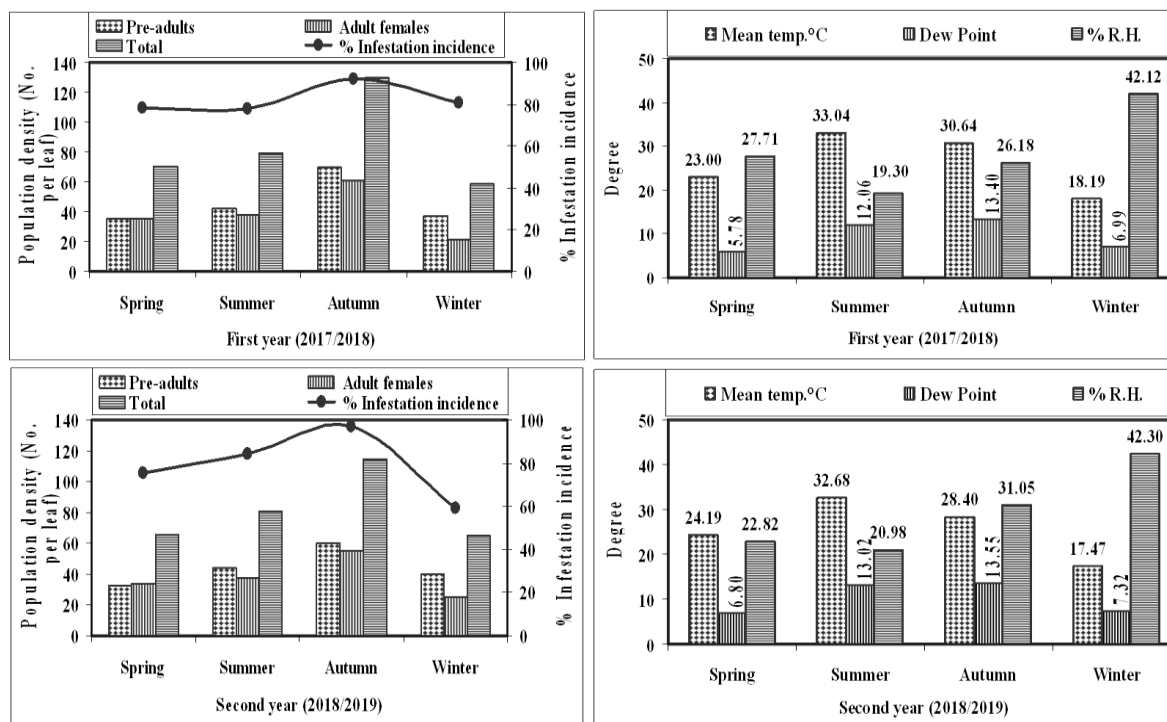


Fig. 2. Population density of *A. tubercularis* and the percentages of infestation incidences counted on mango leaves at Esna district, Luxor Governorate during the two successive years (2017/2018 and 2018/2019).

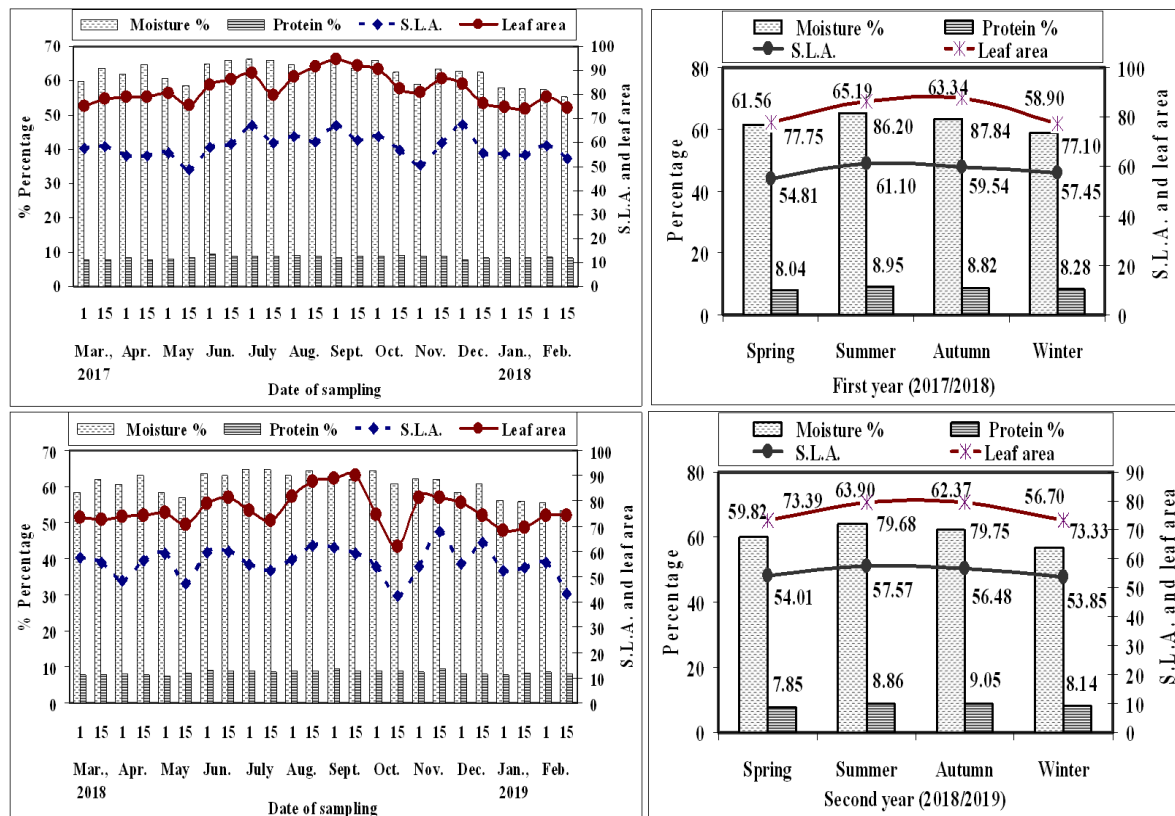


Fig. 3. Means of half monthly counts of physical and chemical measurements on mango leaves at Esna district, Luxor Governorate during the two successive years (2017/2018 and 2018/2019).

Table 3. Rates of monthly variation (R.M.V.P) in the mean number of *A. tubercularis* and the infestation incidence percentages estimated on mango trees, with climatic factors, physical and chemical measurements at Esna district, Luxor Governorate through the two years of (2017/2018 and 2018/2019).

Year	Month of inspection	Rate of monthly variation (R.M.V.P.)				Means of weather factors			Means of physical and chemical properties			
		Immature stages (Pre-adults)	Mature stage (Adult females)	Total	Infestation incidence (%)	Mean temp.	% R.H.	Dew point	S.L.A. (cm ² /g)	Leaf area (cm ²)	Moisture (%)	Protein (%)
2017/2018	Mar.	—	—	—	—	19.14	35.71	4.50	57.99	76.46	61.71	7.79
	April	2.16	1.31	1.64	1.18	22.71	28.78	5.94	54.44	78.93	63.32	8.09
	May	0.94	0.63	0.78	0.91	27.14	18.63	6.90	52.02	77.86	59.65	8.23
	June	0.91	1.44	1.12	0.95	31.79	17.75	10.11	58.69	85.10	65.42	9.11
	July	1.18	0.69	0.92	1.04	32.69	19.67	12.21	63.40	84.23	66.14	8.77
	Aug.	1.02	1.66	1.26	1.07	34.65	20.46	13.86	61.22	89.29	64.02	8.97
	Sept.	1.58	1.32	1.45	1.09	33.56	22.67	14.48	63.81	93.27	64.68	8.66
	Oct.	0.97	1.12	1.04	1.03	31.18	25.57	13.66	59.59	86.41	64.11	8.97
	Nov.	1.00	0.80	0.91	1.01	27.18	30.29	12.06	55.21	83.85	61.21	8.82
	Dec.	0.82	0.66	0.75	0.98	21.01	37.19	8.74	61.49	80.32	62.60	8.08
	Jan.	0.58	0.52	0.56	0.90	15.90	44.05	5.64	55.08	74.36	57.75	8.30
	Feb.	0.67	0.56	0.63	0.82	17.67	45.12	6.59	55.78	76.63	56.34	8.47
2018/2019	Mar.	—	—	—	—	20.84	26.89	5.50	56.53	73.02	60.12	7.67
	April	1.37	1.02	1.18	1.10	24.00	23.32	6.86	52.23	74.00	61.79	8.03
	May	0.67	0.82	0.74	0.88	27.74	18.25	8.04	53.28	73.16	57.54	7.86
	June	1.58	1.14	1.35	1.16	33.28	16.00	10.58	59.82	80.13	63.30	9.02
	July	0.88	0.77	0.83	0.95	32.59	24.04	14.44	53.42	74.12	64.62	8.72
	Aug.	1.39	1.99	1.64	1.16	32.19	22.88	14.03	59.46	84.77	63.78	8.84
	Sept.	1.36	1.10	1.23	1.10	32.39	26.36	15.49	60.32	89.44	62.41	9.15
	Oct.	0.60	0.84	0.70	0.96	28.96	29.34	13.40	48.17	68.36	62.62	8.84
	Nov.	1.55	1.31	1.42	0.99	23.84	37.46	11.75	60.94	81.44	62.10	9.16
	Dec.	0.68	0.52	0.61	0.72	19.75	45.42	10.49	59.22	76.77	59.59	8.06
	Jan.	0.53	0.41	0.48	0.76	15.56	47.62	6.62	52.89	68.99	55.99	8.00
	Feb.	2.16	2.08	2.13	1.07	17.09	33.86	4.85	49.44	74.25	54.52	8.34

Table 4. Different models of correlation and regression analyses for describing the relationship between the main weather factors, physical and chemical properties for mango leaves on the total population density of *A. tubercularis*.

Year	Tested counts	Simple correlation and regression values				Partial correlation and regression values					Efficiency %	Rank	Analysis variance				
		r	b	S.E	t	a	P. cor.	P. reg.	S.E	t			F value	C.V.	MR	R ²	E.V. %
First	Mean temp.	0.58	2.87	0.86	3.33 **	8.45	-0.56	-8.04	3.02	-2.66 *	5.88	4	15.00 **	0.17	0.93	0.87	86.78
	% R.H.	-0.44	-1.48	0.64	-2.30 *		-0.28	-1.63	1.42	-1.15	1.09	7					
	Dew Point	0.72	6.58	1.37	4.82 **		0.68	12.92	3.48	3.72 **	11.43	3					
	S.L.A.	0.36	2.47	1.38	1.79		-0.72	-5.54	1.35	-4.10 **	13.92	1					
	Leaf area	0.74	3.97	0.76	5.23 **		0.71	5.11	1.28	3.98 **	13.14	2					
	% Moisture	0.57	5.87	1.81	3.24 **		0.55	5.12	1.96	2.62 *	5.68	5					
	% Protein	0.39	29.24	14.84	1.97		-0.49	-24.19	10.70	-2.26 *	4.25	6					
Second	Mean temp.	0.40	1.79	0.87	2.05	-80.50	-0.63	-11.90	3.70	-3.22 **	9.53	2	13.21 **	0.61	0.92	0.85	85.26
	% R.H.	-0.09	-0.27	0.61	-0.45		-0.54	-4.02	1.57	-2.55 *	6.00	5					
	Dew Point	0.59	4.53	1.31	3.46 **		0.55	12.11	4.55	2.66 *	6.52	4					
	S.L.A.	0.25	1.16	0.98	1.19		-0.54	-2.01	0.79	-2.55 *	5.92	6					
	Leaf area	0.73	3.13	0.63	4.96 **		0.76	3.51	0.76	4.64 **	19.66	1					
	% Moisture	0.40	3.44	1.68	2.05		0.32	2.31	1.69	1.36	1.70	7					
	% Protein	0.63	31.10	8.23	3.78 **		0.57	19.50	7.06	2.76 *	7.05	3					
Two cumulative years	Mean temp.	0.50	2.36	0.60	3.91 **	15.52	-0.65	-11.67	2.14	-5.44 **	15.39	3	21.75 **	0.18	0.89	0.79	79.20
	% R.H.	-0.28	-0.88	0.44	-1.98		-0.57	-3.90	0.88	-4.43 **	10.21	4					
	Dew Point	0.65	5.45	0.94	5.79 **		0.69	13.66	2.27	6.01 **	18.78	2					
	S.L.A.	0.30	1.64	0.78	2.11 *		-0.48	-2.29	0.66	-3.47 *	6.23	5					
	Leaf area	0.69	3.02	0.47	6.41 **		0.72	3.68	0.56	6.51 **	22.01	1					
	% Moisture	0.49	4.47	1.19	3.76 **		0.30	2.23	1.13	1.97	2.02	6					
	% Protein	0.50	30.49	7.70	3.96 **		0.14	5.87	6.33	0.93	0.44	7					

r = Simple correlation; b = Simple regression; P. cor. = Partial correlation; MR = Multiple correlation; P. reg. = Partial regression C.V. = Coefficient of Variation; R² = Coefficient of determination; E.V.% = Explained variance; S.E = Standard error
 * Significant at P ≤ 0.05 ** Highly significant at P ≤ 0.01

Table 5. Different models of correlation and regression analyses for describing the relationship between the main weather factors, physical and chemical properties for mango leaves on the percentages of infestation incidence by *A. tubercularis*.

Year	Tested counts	Simple correlation and regression values				Partial correlation and regression values					Efficiency %	Rank	Analysis variance				
		r	b	S.E	t	a	P. cor.	P. reg.	S.E	t			F value	C.V.	MR	R ²	E.V. %
First	Mean temp.	0.21	0.29	0.29	1.01	152.5 *	-0.72	-4.56	1.11	-4.12 **	24.70	2	7.56 **	0.06	0.88	0.77	76.79
	% R.H.	-0.11	-0.10	0.20	-0.53		-0.51	-1.23	0.52	-2.37 *	8.16	3					
	Dew Point	0.46	1.16	0.48	2.41 *		0.76	6.01	1.27	4.73 **	32.43	1					
	S.L.A.	0.29	0.55	0.39	1.40		-0.47	-1.06	0.49	-2.14 *	6.65	4					
	Leaf area	0.47	0.70	0.28	2.51 *		0.42	0.88	0.47	1.87	5.09	5					
	% Moisture	0.36	1.03	0.57	1.82		0.40	1.25	0.72	1.75	4.44	7					
	% Protein	0.13	2.65	4.41	0.60		-0.42	-7.18	3.92	-1.83	4.90	6					
Second	Mean temp.	0.73	1.79	0.36	4.99 **	-16.90	-0.41	-4.28	2.40	-1.79	4.08	3	8.84 **	0.11	0.89	0.79	79.45
	% R.H.	-0.42	-0.67	0.31	-2.19 *		-0.40	-1.79	1.02	-1.75	3.93	4					
	Dew Point	0.75	3.16	0.59	5.39 **		0.42	5.43	2.95	1.84	4.34	2					
	S.L.A.	0.20	0.51	0.54	0.94		-0.34	-0.76	0.51	-1.47	2.77	6					
	Leaf area	0.55	1.30	0.42	3.10 **		0.37	0.77	0.49	1.58	3.17	5					
	% Moisture	0.74	3.51	0.67	5.23 **		0.48	2.39	1.10	2.18 *	6.11	1					
	% Protein	0.62	16.78	4.57	3.67 **		0.25	4.76	4.57	1.04	1.39	7					
Two cumulative years	Mean temp.	0.51	1.01	0.25	4.03 **	-22.42	-0.34	-2.92	1.27	-2.30 *	5.53	4	7.94 **	0.11	0.76	0.58	58.16
	% R.H.	-0.30	-0.39	0.18	-2.13 *		-0.24	-0.83	0.52	-1.60	2.66	6					
	Dew Point	0.61	2.14	0.41	5.22 **		0.39	3.65	1.34	2.72 **	7.71	2					
	S.L.A.	0.25	0.57	0.33	1.72		-0.34	-0.88	0.39	-2.27 *	5.35	5					
	Leaf area	0.51	0.94	0.23	4.06 **		0.35	0.79	0.33	2.38 *	5.89	3					
	% Moisture	0.60	2.30	0.46	5.05 **		0.47	2.23	0.67	3.33 **	11.58	1					
	% Protein	0.46	11.67	3.30	3.54 **		0.09	2.02	3.74	0.54	0.31	7					

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