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Seasonal Activity and Sensitivity of Some Tomato Cultivars to *Tetranychus urticae* Koch

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Abstract. The results of the current study showed that the first appearance of *Tetranychus urticae* on the tomato plants leaves in the field was on 14/7/2020 and that the highest average number of mites was reached 371.78 mite per/10 leaves on, while the lowest average recorded was 23.19 individuals per /10 leaves on 5/10/2020 and for the comparison between varieties Naba variety had highest average (240.05 individuals),in compare with the local variety which had the lowest average of individual mite which was102.26mite. The correlation was positive and significant between the number of mites and the average weekly temperature (0.750) * And the significant was negative (0.685 * -) with the relative humidity. The lowest mean of infestation was on the tomato cultivars Sandra (69.97%) and GS (63.05%). Based on the criteria of % of infested leaves and mite population density, the tomato cultivars GS and local were the least sensitive to infection, respectively. The correlation values were insignificantly negative between of the affected leaves and the content of these leaves of proteins (-0.262), carbohydrates (-0.476) and flavonoids (-0.221), while it was significant positive with phenols (0.751) and insignificantly positive with alkaloids (0.432).

Keywords: Tomato Cultivars , Seasonal Activity , *Tetranychus urticae* Koch.

Introduction

The Solanaceae family includes about 2000 species and 75 genera of different plants, including annuals and perennials. South America is the original home and from which it spread to other parts of the world. Most of the plants of this family are of economic importance because they are a major source of food or for extracting medicines or as ornamental plants, including tomatoes, potatoes and peppers as Essential vegetables. (George, 2011). The tomato, *Lycopersicom esculantum,* is one of the most important crops of the nightshade family and of the most important major vegetable crops in the world and Iraq. The European Union countries are of the most important producers of tomato. More than 85% of the tomato is produced in open fields, especially in the Mediterranean countries (Euro stat, 2019) mentioned in Litskas at al (2019). In Iraq, the cultivated area in 2018 reached (17421.5) thousand hectare, and the amount of production reached (467,579) tons, with an average productivity of 1679.1 kg/hectare (Central Statistics Organization, 2018). The cultivated area in Iraq is constantly increasing as a result of the increased demand for this crop. The cultivated area increased from 34 thousand hectares on average for the years 1974-1975 to nearly 66 thousand hectares in 2003, with an average production per hectare of 11.86 tons (Majid, 2010). In Nineveh Governorate, the cultivated area for 2019was amounted to (7505) hectare, and the amount of production was amounted to (12,080) tons (Nineveh Directorate of Agriculture/ Planning 2019,). The tomato crop is affected by many pests, the most important of which is the two-spotted spider mite *Tetranychus urticac* (koch) family Tetranychidae of the order Parasitiformes, this type of mite spreads all over the world and attacks more than 1200 species of the economically important plants (Alzoubi, Cobanoglu,2008) and more than 300 plant species attacked by this pest are of economic importance (Gavnjet, 2012). This mites was first diagnosed by the scientist Koch in 1836 (Modal, 2006). The production of resistant cultivars is one of the important and alternative methods of controlling mites as they are environmentally safe and have no side effects, as well as their compatibility with other control

methods within the integrated pest management programs (Adkisson, 2006). Plant characteristics are direct plant defenses that affect the vitality of herbivorous pests such as mechanical resistance on the plant surface (such as hairs, thorns and leaf thickness) or the production of toxic chemicals such as terpenes, alkaloids, phenols, anthocyanins, ketones, which either kill, expel or impede growth and development of these herbivores (Hanley, et al. 2007). Indirect plant defenses are represented by releasing a group of volatile substances that attract the vital enemies of these pests (mites and insects) and plants respond to herbivores through many biochemical and partial morphological mechanisms in an attempt to repel or counteract the effects caused by the attacking pests (War et al., 2012). Therefore, the current study aims to study the seasonal activity of red spider mites on some varieties of tomato and to determine the best of these varieties in terms of their sensitivity to infection with red spider dream with two spots and its relationship to the varieties leaves content essential nutrients.

Materials and Methods

The study was carried out on a farm dedicated to the cultivation of tomatoes belonging to one of the farmers in the area located on the Mosul-Dohuk road during the 2020 agricultural season. Six varieties of the well-known and popular tomato were grown by the farmers of Nineveh. They are Maysam, Nabaa, Sandra, Nora, GS, which are imported varieties obtained from the local markets, and the sixth local variety obtained from the Directorate of Agriculture of Dohuk. All agricultural operations related to the cultivation of tomatoes in the open fields were conducted and according to the recommendations for cultivation and service of the crop and the timings in force by the farmers of the region, The land was divided into six treatments and three replications for each treatment, based on the completly randomized design, taking into account the non-use of pesticides. The seeds of the six tomato varieties (Gs-Nora-Maysam-Nabaa-Sandra-Locally) were first planted in the nursery on 29/2/2020, then the tomato seedlings were transferred to the permanent field on 21/4/2020, where they were planted on meadows with a length of 25 m per meadows (Rows). for each variety on both sides of the rice, and the distance between one plant and another is 25 cm, and between one line and another 1.5 m. The drip irrigation method used by tomato growers in the region was adopted. Samples were carried out weekly. One sample included (30) leaves (10 leaves for each duplicate) taken at random from each variety. Sampling started after the first appearance of the infestation in the field and until the end of the season. The samples were placed in polyethylene bags and placed in a box containing a little ice until they were delivered. To the laboratory and put it in the refrigerator until the examination is carried out using the usual microscope. The moving individuals of the two-spotted are counted and recorded. The percentage of infected leaves was calculated using the equation: % infection = number of infected leaves / number of leaves in the sample x 100. The relative sensitivity of the cultivars was calculated on the basis of % of infested leaves and the numerical density of mites as follow:

Relative sensitivity /infection rate = average infection rate for the variety / least average infection rate.

Relative sensitivity /number of individuals = average number of mites individuals /least average number of individuals., the daily averages of temperature and relative humidity were obtained from the Meteorological Department in Nineveh Governorate, located in the Rashidiya area.

Detremination of the leaves content of proteins, carbohydrates, phenols, flavonoids and alkaloids:

All experiments were carried out in the Entomology Research Laboratory /Plant Protection Department and the Central Laboratory of the College of Agriculture and Forestry during the year 2020:

For the implementation of this study, samples were collected from the leaves of tomato plants of the six varieties used in the study separately, in addition to the comparison treatment.: These samples were brought to the laboratory after placing them in polyethylene bags and writing the information for each treatment,as they were washed well to remove the unwanted impurities on them when they were left after brushing them on a smooth surface and under the temperature of the laboratory to dry, after that and using an electric mixer.

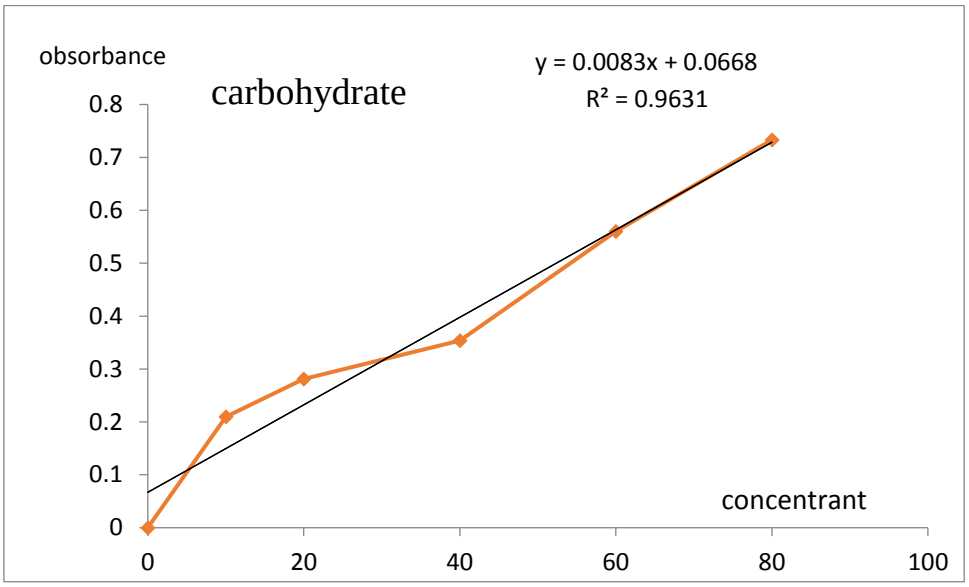
Protein determination: Protein was determined by the method (Ryan and Stephen., 2003)included.The stages of digestion and scaling and calculating the percentage of protein in the sample according to the following equation:

Crude protein percentage = (6.25 x 50 x 14 x volume x standard acid) / (100 x sample weight) x 100.

Carbohydrate Determination:

Carbohydrates were estimated using the Dubios method (1956), which included the preparation of a standard solution of glucose sugar by dissolving 0.1 g of glucose in 100 distilled ml to obtain a

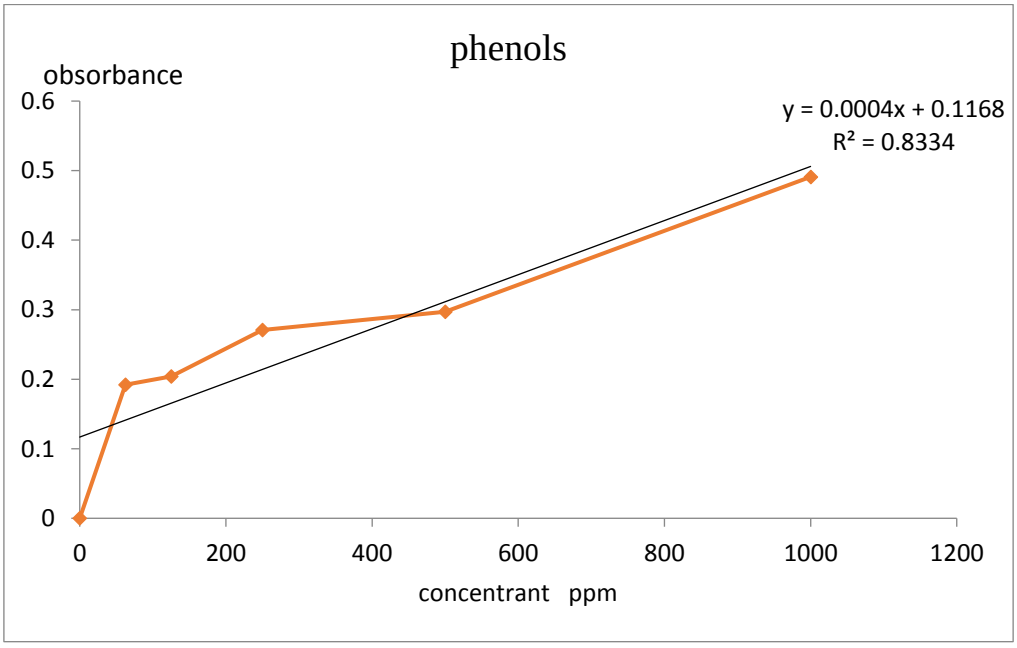
concentration of 1000 ppm and then preparing a series of standard solutions 20, 40, 50, 80 ppm. Reading by Spectro photo meter at a wavelength of 490 nm and then drawing the standard curve based on the results of reading the standard solutions.



Standard curve for glucos

Determination of phenols:

The total phenol content of leaves was estimated according to (Singleton et Rossi, 2009) method mentioned in Manal and Maria(2017)., which was based on the (Fotin-ciocalteu) reagent. The standard solution of galic acid was prepared by dissolving 0.008 g of gallic acid (GAI) in 2 ml distilled to obtain a concentration of 4000 ppm and from it a series of standard solutions 62.5, 125, 250, 500, and 1000 ppm were prepared to obtain the ethanolic sample extract. Measurement on a Spectro photometer at 750 nm and then drawing the curve for concentrations in terms of absorbance.

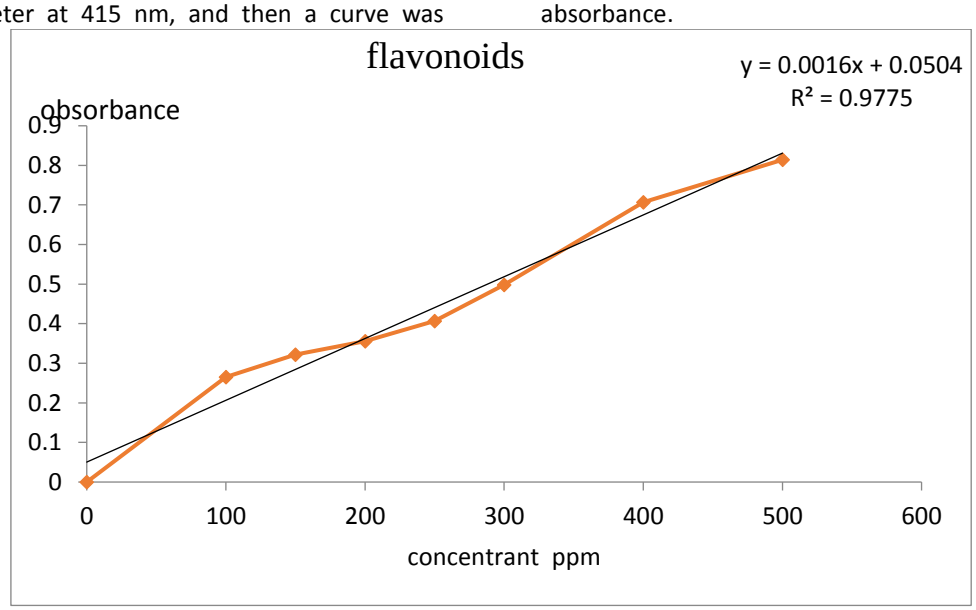


Standard curve of gallic acid

Determination of flavonoids:

Then estimate Flavonoids according to the method of woiskyr et salation (1998) mentioned in Manal and Maria(2017) and the preparation of the solution for standard Kiorstein by dissolving 0.005 g of Alcursthyn in 10 mL ethanol we get the concentration of 500 ppm and then prepare a series of solutions standard 50 ,100 ,150 , 200 ,250

,300 , 400, 500 ppm and measured on a Spectro photo meter at 415 nm, and then a curve was drawn for the concentrations in terms of absorbance.



standard curve of quercetin

Estimation of Alkaloids:

Alkaloids were estimated according to Mattilla (2007) method and mentioned in Al-Samarrai (2017):

Percentage of alkaloids = (alkaloid weight)/(sample weight) x100.

Statistical Analysis:

The results of the field study were analyzed using the factorial random sector design and laboratory experiments using the complete random design, and the results were statistically analyzed using the calculator according to the SAS (Statistical Analysis System) and compared the averages using the Duncan test Antar(2010).

Results and Discussion:

1-Seasonal Activity of Two-Spotted Spider Mites on Some Tomato Cultivars :

The first appearance of mite infestation on the leaves of tomato plants in the field was on 14/7/2020, that is, about 11 weeks after transferring the seedlings to the permanent field, which was on 21/4/2020, where sampling continued weekly from 20/7 to 17/ 8. After that, sampling was stopped, which lasted until 7/9, due to the drying of the crop and yellowing and falling of tomato leaves. Sampling continued after 7/9 until the end of the season on 26/10 and after the plants recovered. The results of Table (1) indicate that there are significant differences in the average weekly numbers of individuals for the six studied tomato varieties, where the highest average was recorded on 17/8/2020, which amounted to 371.78 individuals/10 leaves at an average temperature of 32.45 C and relative humidity of 28.21% (Figure 1) Which differed significantly from all the averages of individuals in the other weeks, while the lowest average of individuals was recorded on 5/10, which amounted to 23.89 individuals/10 leaves at an average temperature of 24.36C˚and relative humidity of 34.31%, which did not differ significantly from the averages of individuals for the dates 21/9, 28 /9, 12/10, 19/10 and 26/10. The results of Table (1) also showed that there were significant differences between the cultivars in the general average of the number of mites recorded during the season, where the highest general average of the number of mites was recorded in the cultivar Nabaa, which was amounted to 240.05 individuals / 10 leaves, while the lowest average of mites was recorded in the local variety, which was amounted to 102.26 individuals /10 leaves, which did not differ significantly from the average number of individuals in the two cultivars Sandra (119.77 individuals/10 leaves) and GS (127.77 individuals/10 leaves). The results of the statistical analysis showed that there were significant differences in the average number of mites according to the date of taking the sample and the variety, where the highest average number of individuals was recorded on 17/8/2020 on the variety Nabaa, which was amounted to 537.00 individuals/10 leaves at an average temperature of 32.45C˚ and relative humidity of 28.21%, which differed significantly from all other average mite numbers except for the average of the same variety on 27/7 (504.67 individuals/10 leaves) at an average temperature of 36.52oC and a relative

humidity of 24.14%, and the average number of mites for the variety Maysam on 17/8 (484.67 individuals/10 leaves) where no was differences between them were significant and the lowest average number of individuals recorded on cultivar GS on 12/10, which was amounted to 0.33 individuals/10 leaves averaged at a temperature of 22.86 C and a relative humidity of 40.23%.

Yassin et al. (2014) mentioned that there are significant differences in the number of mites on tomato varieties, where the largest number of individuals was recorded on the cultivar Rawan, which was amounted to 130.80 individuals / leaf, while the lowest number of individuals on the cultivar Super gekal was recorded at 34.00 individuals / leaves. Whereas, an average infestation of (81.50 individuals/leaf) was recorded on the cultivar Meram, and the first appearance of the infection was on the cultivar Meram in the third week of September (3.6 individuals/leaf) and continued to increase to reach the peak of its number (383.7 individuals/leaf) in the second week of November.

Sweelam (2020) mentioned that all varieties of school tomato were infected with spider mites throughout the two agricultural seasons, and that the number of mites reached its peak during the months of April and May, and the cultivar Sama was the most susceptible to infection with a rate of 36.71%.

Haque et al. (2011) mentioned that the highest number of mites was during the month of August and that the increase in mite numbers is associated with an increase in temperature. The results of the analysis of the correlation between mite numbers and the weekly averages of temperature and relative humidity showed a significant negative correlation between mite numbers and relative humidity, which was amounted to (-0.685), while this correlation was positively significant between mite numbers and temperature, reaching (0.750).

From the above it is clear that the activity of the mite increased clearly on tomato varieties for the period from 27/7 to 7/9/2020 at average temperatures ranging between 32.02-36.52 C and average relative humidity ranging between 24.14-33.81% (Figure 1) and it appears that it is heat and humidity that are suitable for the growth and reproduction of mites. These facts are consistent with what was mentioned by Almallah (2009) that only moderate temperature enables mites to increase and multiply.

Table 1. Seasonal Activity of Two-Spotted Red Spider Mite on Tomato Cultivars.

samples date	Individual / 10 Leaves Varieties						General Means of Individuals per week
	Nabaa	Nura	Sandra	Mysam	Locally	GS	
20/7	189.33 i-q	247.67 f-m	60.00 s-z	63.33 s-z	29.00 u-z	147.67 m-t	123.17 D
27/7	504.67 A	269.67 e-j	216.00 g-n	209.33 h-o	143.33 n-t	154.33 l-s	249.56 C
3/8	393.67 b-c	281.33 d-i	365.00 c-e	321.00 c-f	203.00 i-p	371.67 c-e	322.61 B
10/8	223.33 c-f	367.00 c-e	372.67 c-d	346.30 c-f	185.33 i-q	329.67 c-f	320.72 b
17/8	537.00 A	377.00 c-d	275.00 f-k	484.67 a-b	253.00 f-l	322.00 c-f	371.78 a
7/9	373.33 c-d	310.67 c-h	82.67 r-z	322.67 c-f	209.33 h-o	121.67 n-v	236.72 c
14/9	115.00 n-w	314.33 c-g	75.67 r-z	168.33 j-r	111.00 o-x	144.67 n-t	154.83 d
21/9	127.67 n-u	97.33 q-r	23.33 v-z	73.67 r-z	69.00 r-z	15.00 w-z	67.50 e
28/9	116.67 n-w	110.67 o-x	29.00 u-z	36.33 u-z	49.67 t-z	26.00 u-z	61.36 e
5/10	48.67 t-z	106.33 p-y	22.00 v-z	25.33 u-z	23.33 v-z	1.67 Z	23.89 e
12/10	155.67 k-s	141.67 n-t	19.00 w-z	4.33 y-z	38.67 u-z	0.33 Z	59.94 e
19/10	92.67 q-z	64.33 s-z	33.00 u-z	71.67 r-z	12.00 x-z	18.67 w-z	48.72 e
26/10	143.00 n-t	17.33 w-z	2.67 z	106.33 p-y	2.67 Z	7.67 y-z	46.61 e
Mean numbers of: variety	240.05 a	208.26 b	119.77 d	171.79 c	102.26 d	127.77 D	

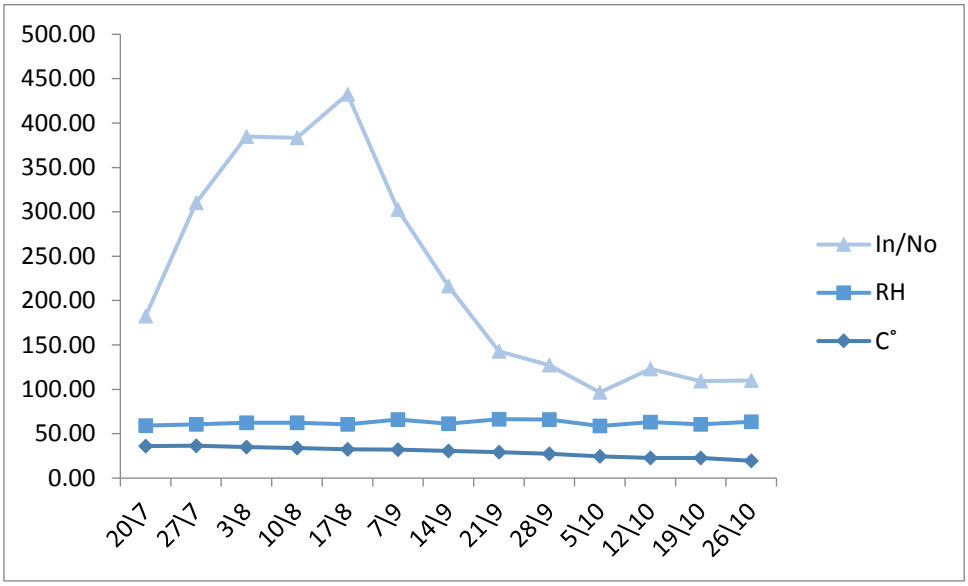


Figure 1. Population Density of Two-Spotted Spider Mites with Average Temperatures and Relative Humidity During the Agricultural season 2019-2020.

2- Effect of Tomato Cultivar on the Percentage of Infected Leaves and the Number of Two-Spotted Spider Mite During the Season 2019-2020.

Table (2) shows that the average percentage of leaves infected with mites on the cultivars Maysam, Nabaa, Sandra, Nora, GS and Locally amounted to 83.31, 90.49, 69.97, 88.44, 63.05 and 75.10%, respectively, and that the lowest average percentage of infestation was recorded on Tomatoes were rated Sandra and GS, which were 69.97 and 63.05, respectively. Statistical analysis using Duncan's test showed that the average percentage of infected leaves on the cultivar Nabaa (90.49%) was greater than the mean on the other cultivars with a significant difference except for the two tomato cultivars Maysam and Nora, where there were no significant differences between them. The same table indicates that the average number of mites reached at 1717.79, 240.05 ,119.77, 208.26, 127.77, 102.26 individuals/10 leaves on the cultivars Maysam Nabaa, Sandra, Nora, GS and Locally, respectively, and that the lowest average mite numbers were recorded on the cultivars Sandra, GS and Locally. The statistical analysis showed that the average number of mites on the variety Nabaa (240.05 individuals/10 leaves) was greater than the average number of mites on the other cultivars with a significant difference, while there was no significant difference in the average number of mites on the cultivars Sandra, GS and Locally,

Studying the correlation between the percentage of infested leaves and the number of two-spotted mite on the six tomato cultivars, found that the correlation was positive and significant (0.856), and this is consistent with many studies that indicated the varying rates of mite infestation with different crops and cultivars for one crop. The study of El. Saiedy (2013) reported on the susceptibility of the infection of eight cultivars of pepper with spider mite, thrips and aphids, where it showed that the Rox yred cultivar was the most susceptible to mites, as it recorded an average of 131.5 and 162.4 individuals/leaf in Giza and Beheira regions.

In a study by Abou-Zaid et al. (2019) on the response of some squash cultivars to spider mite infection for the 2015-2016 seasons in Egypt, Andro174 recorded the highest average number of mites amounting to 139.32 and 122.36 individuals/leaf for the two seasons, respectively.

3- The Relative Sensitivity of the Six Tomato Cultivars to the Infestation of the Two-Spotted Red Spider Mite and the Content of its Leaves of Essential Nutrients.

From Table (3), we find that the GS variety was the least sensitive cultivar, calculated on the basis of the percentage of infested leaves, which was amounted to 1.00, while the tomato variety Nabaa was the most sensitive, reaching at 1.43 based on the criterion of of infested leaves, while the sensitivity values for the rest of the varieties were descending according to this criterion as follows Nora, Maysam, Locally and Sandra. As for the relative sensitivity values of tomato cultivars, calculated on the basis of the density of mite numbers, Table (3) indicates that the local cultivar was the least sensitive of these cultivars, reaching

at 1.00, while the Nabaa cultivar was the most sensitive of these cultivars (2.34), while the rest of the cultivars graded descending in their sensitivity and on the basis of the density of mite numbers as follows: Nora, Maysam, GS and Sandra. From the foregoing, we conclude that the criteria for the percentage of infected leaves and the density of the mites agree to a large extent in determining the relative sensitivity of the studied tomato cultivars, and that the tomato GS and local cultivar was the least sensitive, while the Nabaa cultivar was the most sensitive among all the studied cultivars. In an attempt to determine the reasons for this resistance or sensitivity to the studied tomato varieties, specifically the content of its leaves from some basic nutrients, the results of protein estimation showed that the highest content of protein was in the cultivar Nabaa (5.87g/100g),which did not differ significantly in its protein content from the rest of the other cultivars except for the GS variety (4.71g/100g), where the difference between them was significant. The results of the statistical analysis showed that there were no significant differences between all varieties in their carbohydrate content, which was amounted to 0.53, 0.54, 0.56, 0.53, 0.56 and 0.60 g/100 g for the cultivars Maysam, Nabaa, Sandra, Nora, GS, and locally, respectively, and the Nora variety was characterized by the highest content. Of the phenols, it reached at 13.83 mg/g, with a significant difference from the rest of the cultivars, while the Sandra cultivar was the lowest in its content, reaching at 8.83 mg/m.

Table 2. Effect of Tomato Variety on the General Mean of the Percentage of Infested Leaves and the Number of Mites During the Season 2019-2020.

Varieties	% of infected leaves Range	Mean	General Mean of Individual/ 10 Leaves Range	Mean
Mysam	100—23.3	83.31 c	4.3—484.6	171.79 c
Nabaa	100—73.3	90.49 a	48.6—504.6	240.05 a
Sandra	100—13.3	69.97 e	20.6—372.6	119.77 d
Nora	100—60	88.44 b	17.3—377	208.26 b
GS	100—13.3	63.05 F	0.3---371.6	127.77 d
Locally	100—23.3	75.10 D	2.6--253	102.26 d

Values followed by dissimilar letters in the existing sector indicate the presence of significant differences at the 5% probability level, according to Duncan's test.

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the cultivars Maysam, Nabaa, Sandra, Nora, GS, and locally, respectively, and the Nora variety was characterized by the highest content. Of the phenols, it reached at 13.83 mg/g, with a significant difference from the rest of the cultivars, while the Sandra cultivar was the lowest in its content, reaching at 8.83 mg/m.

The rest of the cultivars graded decreasingly in their content of phenols as follows: Maysam, Nabaa, local and GS (Table 3). As for the content of flavonoids in the leaves of tomato varieties, the local variety was the highest in its content, which was amounted to 4.56 mg / g, with a significant difference from the rest of the other varieties, while the variety Sandra was distinguished by the lowest content of flavonoids, which was amounted to 2.25 mg / g compared to the other varieties, where the difference between them was significant. The rest of the varieties were listed in descending order as follows: GS, Nabaa, Maysam and Nora. As for the alkaloids content of the leaves, the results of the estimation indicated that the highest content was in the cultivar Nabaa (2.18 g/100 g), followed by the variety Maysam (2.02 g/100 g), where the difference between them was not significant and that the lowest content was recorded on the two cultivars Nora (1.76). and GS (1.74), where the difference between them was not significant. The results of the study of the correlation between % of infested leaves and the number density of mites with the content of the aforementioned essential nutrients and mentioned in Table (4) indicate that the correlation values were insignificantly negative between % of infested leaves and the content of these leaves of proteins (-0.262) and carbohydrates (-0.476). The flavonoids (-0.221) were significantly positive with folates (0.751 +) and insignificantly positive with alkaloids (0.432 +). And the correlation values between the n density of mite and the content of tomato leaves of these nutrients were also positive, not significant with carbohydrates (0.010 +), phenols (0.620 +) and alkaloids (0.367 +). From the foregoing, it is clear that the nature of this aforementioned link is not well clear and it is not possible to get out of it with a clear or stable equation for the relationship between the content of tomato leaves for the six types of nutrients and its effects in the sensitivity or resistance of these varieties. This may be due to the fact that the causes of resistance are multiple and cannot be limited to one specific factor, which is consistent with what Lyeznski and others (1990) mentioned in a study on chemical and phenotypic factors of resistance against spider mites in strawberry plants, showed that there was a negative relationship between mite survival, glandular and non-glandular hair density and the concentration of total phenols in leaves. Better through a reaction that combines three of the phenotypic and chemical characteristics of the strawberry plant rather than any individual characteristic

In a study by Ali et al. (2015) on the effect of phytochemical, morphological, and histological components of five tomato hybride, the results showed a positive relationship between the level of mite infection and total carbohydrates in tomato leaves, while a negative relationship was found with alkaloids, total phenolic compounds, flavonoids, and total carotenoids.

Table 3. Relative Sensitivity of The Six Tomato Cultivars to infestation by Two-Spotted Red Spider Mite and The Content of Essential Nutrients in Their Leaves .

varieties	Leaves Content					Relative Sensitivity of the variety based on	
	Proteins gr\100gr	Carbohydrates g\100g	Phenols mg\g	Flavoniods mg\g	Alkaloids g\100g	% of Infected Leaves	Mite Densiy
Mysam	5.01 a--b	0.53 a	12.83 b	3.00 D	2.02 a--b	1.32	1.68
Naba	5.87 a	0.54 a	12.23 b	3.37 C	2.18 a	1.43	2.34
Sandra	5.84 a	0.56 a	8.83 d	2.25 e	1.96 b	1.11	1.17
Nora	5.51 a--b	0.53 a	13.83 a	2.93 d	1.76 c	1.40	2.03
GS	4.71 b	0.56 a	10.83 c	4.06 b	1.74 c	1	1.25
locally	5.01 a--b	0.60 a	12.08 b	4.56 a	1.94 b	1.19	1
average nutrient	5.32	0.55	11.77	3.36	1.93		

Values Follows by dissimilar letters in the same sector indicate the presence of significant differences at the 5% probability level, according to Duncan's test.

Table 4. The correlation between the content of essential nutrients and the percentage of infected leaves and the number density of mites.

Essential Nutrients	% of infected leaves	The Mite Density
Proteins	0.262-	0.010
Carbohydrates	-0.230	-0.470
Phenols	*0.751	0.620
Flavonoids	0.221-	-0.267
Alkaloids	0.432	0.367

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