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Population dynamics of the mite, *Tetranychus urticae* Koch (acarina: tetranychidae) under acaricide treatment on two varieties of peach and one variety of nectarine in the province of El-Hajeb (Morocco)

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Abstract

The population dynamics of *Tetranychus urticae* Koch on two varieties of peach (*Prunus persica* var. Royal Majestic, and *Prunus persica* var. Kaweah) and one variety of nectarine (*Prunus persica var. nucipersica* var. Zephyr) were monitored for three years from 2019 to 2022. The results of this study showed that over the course of these three years, infestation peaks occurred in March and declined later in October. For all three varieties, the infestation profile varied from year to year. The Royal Majestic variety was the most infested by *T. urticae*, with average infestation percentages of 57.06%, 44.11%, and 50.97%, respectively during the three years. As for the two other varieties, the infestation was less pronounced during the three years with average infestation percentages of 31%, 15.42%, and 15.50% on Kaweah and 5.31%, 29.21%, and 26.06% on Zephyr.

The results of intra-plant infestation showed that during that during this study periods, the lower stratum was the one with the highest average infestation percentages, with average infestation percentages of 57.29%, 26.08%, and 28.37% respectively on the Royal Majestic, Zephyr, and Kaweah varieties. Concerning the middle stratum, the percentages of infestation are 53.19%, 19.42%, and 19.96% respectively for the Royal Majestic, Zephyr, and Kaweah varieties. For the upper stratum the percentages of infestation are 47.87%, 11.56%, and 9.54% respectively for the Royal Majestic, Zephyr, and Kaweah varieties.

Keywords: Population dynamics; Rosaceae; Two-spotted spider mite; *Tetranychus urticae*

1. Introduction

In Morocco, peach and nectarine production reaches almost 100,000 tons per year (S. Maazouz, 2016) [1]. Among the main production regions, we note the region of Meknes province of El-Hajeb. Indeed, the cultivation of rosacea remains subject to attacks by several diseases and pests that affect both the quality and quantity of production. Among the enemies of these orchards, we cite the two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae), whose severe attacks are manifested by yellowish leaves, reduced growth rates, and low yield (Bolland et al., 1998) [2]. Faced with this situation, producers often resort to chemical control based on formulations of insecticides with polyvalent action. These excessive interventions are often the cause of increased production costs, poisoning of warm-blooded animals including humans, and have a negative impact on the environment in general. The multiplication of treatments is also responsible for the emergence of resistant strains certain families of products (Wege P and Leonard PK; Bylemans D and Meurrens; Herron GA and Rophail J) [3], [4], [5].

All of the constraints raised now require a new vision for the sanitary protection of rosaceae in Morocco; a protection that must find a judicious compromise between the imperatives of production and marketing on the one hand, and those

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of maintaining a certain natural balance, guaranteeing sustainable agriculture, environmental preservation, and consumer protection on the other hand.

A better identification of pests and knowledge of their development cycles, as well as the sensitive phenological stages of rosaceae, can make it possible to determine the optimal intervention conditions, particularly through an objective assessment of the actual phytosanitary risk incurred in orchards.

It is within this framework that our work is carried out, with the main objective of studying the population dynamics of *T. urticae* under acaricide stress in natural conditions of cultivation on two varieties of peach (Royale Majestic and Kaweah) and one variety of nectarine (Zephyr), while trying to develop an appropriate control strategy that takes into account the different parameters that can influence tree infestation by spider mites. We present the results of three years of study (2019/2020, 2020/2021, and 2021/2022).

2. Material and methods

2.1. Presentation of the study orchard

The study was conducted in Chlihat (II) estate located in the province of El-Hajeb at an altitude of 814 m: 33°42’21.852’’ north and 5°25’4.296’’ south. The estate is characterized by short, very hot, arid and clear summers, and long, chilly, and partly cloudy winters with precipitation. Throughout the year, the temperature generally varies from 2 °C to 32 °C and is rarely below -1 °C or above 37 °C. The estate covers an area of 252 hectares planted with almond, pear, peach-nectarine (Royal Majestic, Zephyr, and Kaweah), persimmon, and olive trees.

Sampling sites consisted of two peach orchards of different varieties, one corresponding to the Royal Majestic (RM) variety and the other to the Kaweah (K) variety, and one nectarine orchard of the Zephyr (Z) variety, each covering an area of 0.5 hectares (Figure 1). Within each orchard, the trees were separated by 5 meters in length and 3 meters in width.

Figure 1 Photo of the location of the chlihat II estates as well as the three study plots (google maps, 2022) [6]

2.2. Chemical treatments

The chemical treatment against mites was carried out by the technical staff of Chlihat II estate according to the schedule shown in Table 1.

Table 1 Schedule of miticide treatments used against mites

Date	Variety	Products	Active Ingredient
14/03/2020	Royal Majestic	Zoro 100 cc/Hl Baroque 35cc/HL Spray oil 100cc/Hl,	Abamectin, Oxazoline, Paraffin oil
28/03/2020	Zephyr	Zoro 100 cc/HL Baroque 35cc/Hl Spray oil 100 cc/hHl,	Abamectin, Oxazoline, Paraffin oil
09/05/2020	Zephyr	Zoro 100cc/Hl Sprayoil 100cc/Hl,	Abamectin, Paraffin oil
26/03/2020	Kaweah	Zoro 100cc/Hl Baroque 35cc/Hl Sprayoil 100cc/Hl,	Abamectin, Oxazoline, Paraffin oil
04/06/2020	Kaweah	Zoro 100cc/Hl Sptayoil 100cc/Hl,	Abamectin, Paraffin oil
06/04/2021	Kaweah, Zephyr, Royal Majestic,	Zoro 100 cc/Hl Baroque 35cc/HL Spray oil 100cc/Hl,	Abamectin, Oxazoline, Paraffin oil
15/05/2021	Zephyr, Royal Majestic	Zoro 100 cc/HL Baroque 35cc/Hl Spray oil 100 cc/hHl,	Abamectin, Oxazoline, Paraffin oil
24/04/2021	Kaweah	Zoro 100cc/Hl Spray oil 100cc/Hl,	Abamectin, Paraffin oil
15/07/2021	Kaweah	Zoro 100cc/Hl Baroque 35cc/Hl Spray oil 100cc/Hl,	Abamectin, Oxazoline, Paraffin oil
24/07/2021	Zephyr	Zoro 100cc/Hl Spray oil 100cc/Hl,	Abamectin, Paraffin oil
15/05/2022	Zephyr	Numectin 100 cc/Hl Spray oil 100 cc/HL,	Abamectin, Paraffinic oil
17/05/2022	Kaweah	Dynamic 50 cc/hl Baroque 35 cc/HL Spray oil 100cc/hl,	Abamectin, Oxazoline, Paraffin oil
05/06/2022	Zephyr	Numectine 100cc/hl Insecticide 101 100cc/hl Dynamic 50cc/hl,	Abamectin, Paraffinic oil
11/06/2022	Kaweah	Numectin 100cc/hl Insecticide 101 100cc/hl Dynamic 50cc/hl,	Abamectin, Paraffinic oil

2.3. Sampling and study of *T. urticae* dynamics

2.3.1. Study of tree colonization rate

Estimation of mite populations on tree foliage should be done by visually observing the leaves. The method involves taking a sample of 10 leaves from each of 10 randomly selected trees per variety once a week, equivalent to a total of 100 leaves. During each sampling, the leaf samples from each tree are placed in a labeled bag. The contents of each bag are later observed under a binocular microscope at magnifications of 15, 20, and 40 in order to identify different stages of *T. urticae* (Sato et al. 2007) [7]. The number of leaves contaminated by any of the stages is counted.

2.3.2. Study of the intra-tree colonization rate

The presence of *T. urticae* on each variety was recorded at weekly intervals, from March 2020 to September 2022. At each sampling date, and for each tree, 10 leaves were sampled from each of the three tree strata (lower stratum, middle stratum, and upper stratum) on 10 randomly selected trees per variety, equivalent to 300 leaves per cultivar plot. At each sampling, the leaf samples from each stratum were placed in a bag and labeled. The content of each bag was subsequently observed under a binocular microscope at magnifications of 15, 20, and 40 in order to identify the different stages of *T. urticae*. The number of leaves contaminated by any stage of *T. urticae* in each stratum was counted.

2.4. Data analysis

Experimental data were compared using two-way analysis of variance with the Statview V5.0 software. If the adjusted probability is less than 0.05, the difference is considered significant. If the adjusted probability is greater than 0.05, the difference is considered non-significant.

3. Results

3.1. Tree colonization rate by *T. urticae*

The results of the average percentage of infestation per plot show that the emergence of *T. urticae* on the two varieties of peach (Royal Majestic and Kaweah) and the variety of nectarine (Zephyr) begins in mid-March during the three years of study, acaricide, larvicide and ovicide treatments are always carried out by the technician during this period in order to avoid peaks in the emergence of mites, following the emergence of adults and eggs from diapause (Figure 2).

On examining Figure 2, it appears that the infestations of the three varieties studied vary from year to year. The Royal Majestic variety shows the highest infestation percentages reaching a peak of 100% in May, this value persists until September where the infestation percentage gradually decreases until the mites disappear in early November following re-entry into diapause (Figure 2). These results are the same over the three years for the Royal Majestic variety. The persistent high percentages are due to the scarcity of acaricide treatments on this variety.

The Kaweah variety shows 3 peaks of infestation during the year 2020, a first peak recorded on March 13 (46%), a second peak on May 28 (78%), and a third peak on May 26. August (90%), a zero-infestation percentage was recorded in early October despite the absence of an acaricide treatment. During the year 2021 two infestation peaks were recorded on the Kaweah variety on April 18 and July 15 with percentages of 50% and 90% respectively. The same for the years 2022, two peaks of infestation are recorded on the dates May 11 and June 2 with the percentages of 52% and 72% respectively.

The percentage of infestation on the Zephyr variety shows almost the same pace during the three years of study, two peaks of infestation were recorded each year. The percentages of infestation corresponding to the peaks are respectively: 16% on March 13 and 48% on May 5 for the year 2020, 89% on May 1 and 100% on July 15 for the year 2021, 60% on May 11 and 88% on June 2 for the year 2022.

The falls in the high values of the infestation are due to the acaricide treatment carried out after the recording of a value exceeding the intervention threshold limited to 30%.

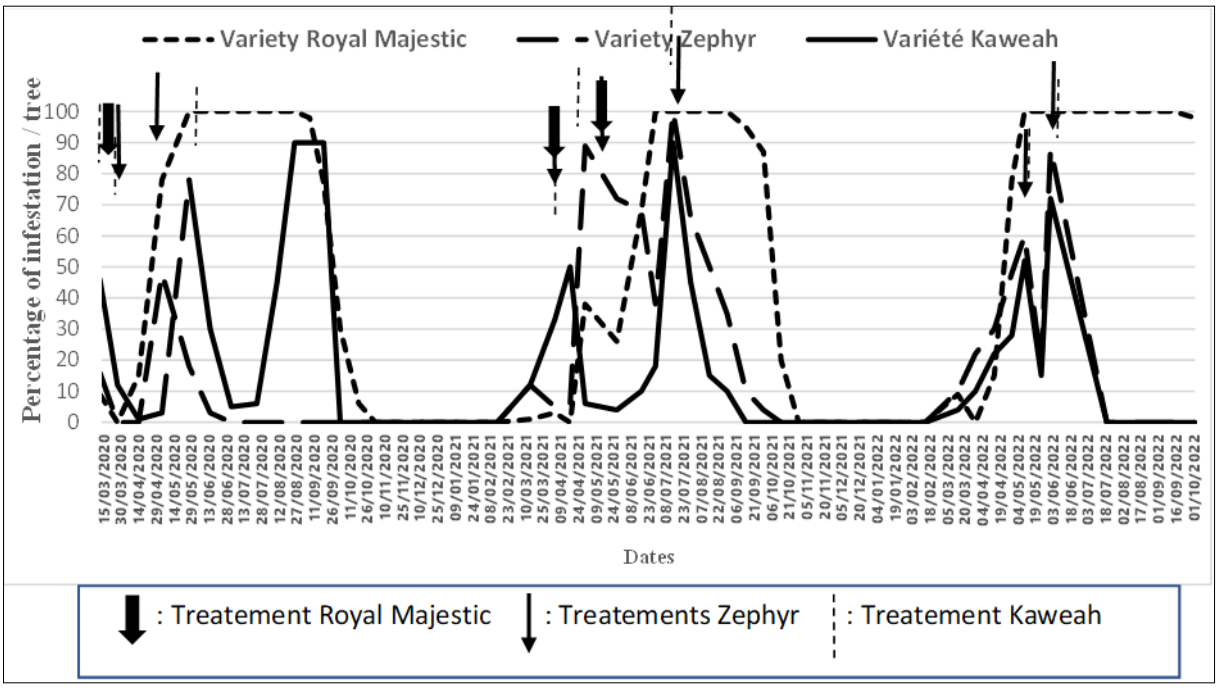

Figure 2 Average percentage of T. urticae infestation over three years on different hosts.

By carrying out an analysis of variance (ANOVA II) taking as classification criteria the varieties studied and time, it appears that the average percentage of infestation observed on 100 leaves per week varies significantly between the Royal Majestic variety and the two other varieties. (Zephyr and Kaweah), on the other hand, the varieties Zephyr and Kaweah do not differ statistically from each other.

3.2. Intra-plant colonization rate

The results in Figure 3 show almost the same profile over the three years of study. The lower stratum is the stratum that presented the highest percentages of infestation, with the average percentages per year 62.94%, 48%, and 63.92% for the years 2020, 2021, and 2022 respectively. Followed by the middle stratum with average percentages per year 57.81%, 42.89%, and 58.15% for the years 2020, 2021, and 2022 respectively. The upper stratum is the least infested stratum with average infestation percentages of 50.44%, 38.68%, and 58.15% for the years 2020, 2021, and 2022 respectively.

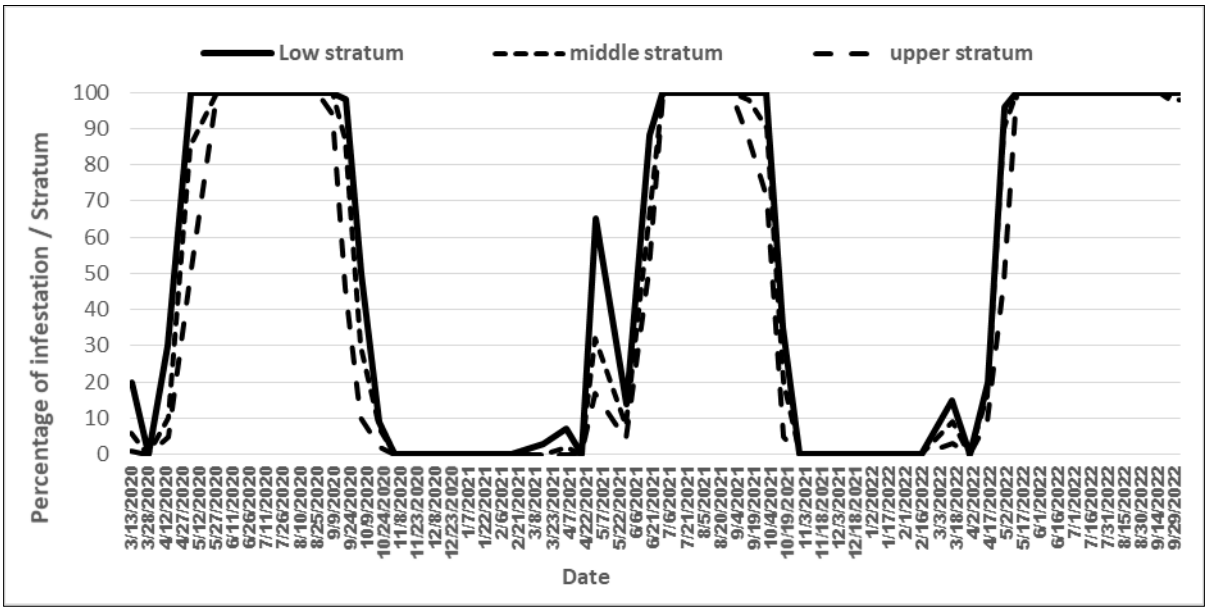

Figure 3 Infestation evolution of the strata of Royal Majestic variety

The results in Figure 4 show that the pattern of the infestation percentages changes from one year to another, the lower stratum is the one that shows the highest infestation percentages with average percentages per year 7.62 %, 38%, and 31.38% for the years 2020, 2021, and 2022 respectively. The middle stratum comes second with the average percentages of infestation per year 4.87%, 30.68%, and 20.84% during the years 2020, 2021, and 2022 respectively. The upper stratum is the least infested with average percentages per year of 2.87%, 18.95%, and 11.46% for the years 2020, 2021, and 2022 respectively.

The results in Figure 5 show that the lower stratum is the stratum which presented the highest percentages of infestation, with the average percentages per year 38.12%, 23.31%, and 23.77% for the years 2020, 2021, and 2022 respectively. Followed by the middle stratum with average percentages per year 72.87%, 15.74%, and 16.38% for the years 2020, 2021, and 2022 respectively. The upper stratum is the least infested stratum with average infestation percentages of 14.62%, 7.21%, and 6.69% for the years 2020, 2021, and 2022 respectively.

The results of the figures of the infestation of the three shrub strata (low stratum, medium stratum, and high stratum of each variety show that the latter constitute a refuge for mites. The low stratum is the one with the highest infestation percentages. high with average infestation percentages of 62.5%, 28.45%, and 30.95% for the Royal Majestic, Zephyr, and Kaweah varieties respectively, followed by the middle stratum with percentages of 58.02%, 21.18%, and 21.8% for the Royal Majestic, Zephyr, and Kaweah varieties respectively and finally the upper stratum with percentages of 52.22%, 12.61%, and 10.41% for the Royal Majestic varieties, Zephyr, and Kaweah respectively.

The comparison of the strata of each variety shows that the Royal Majestic variety is the one with the highest percentages of infestation on the three strata: for the lower stratum we recorded 62.5% on Royal Majestic, 30.95% on Kaweah and 28.45% on Zephyr, for the medium stratum the infestation percentages are 58.02% on Royal Majestic, 21.77% on Kaweah and 21.18% on Zephyr. On the upper stratum the percentages found are 52.23% on Royal Majestic, 10.41% on Kaweah, and 12.61% on Zephyr. The Zephyr and Kaweah varieties show almost the same infestation percentages in the three strata with a slight difference of ± 2 for each stratum.

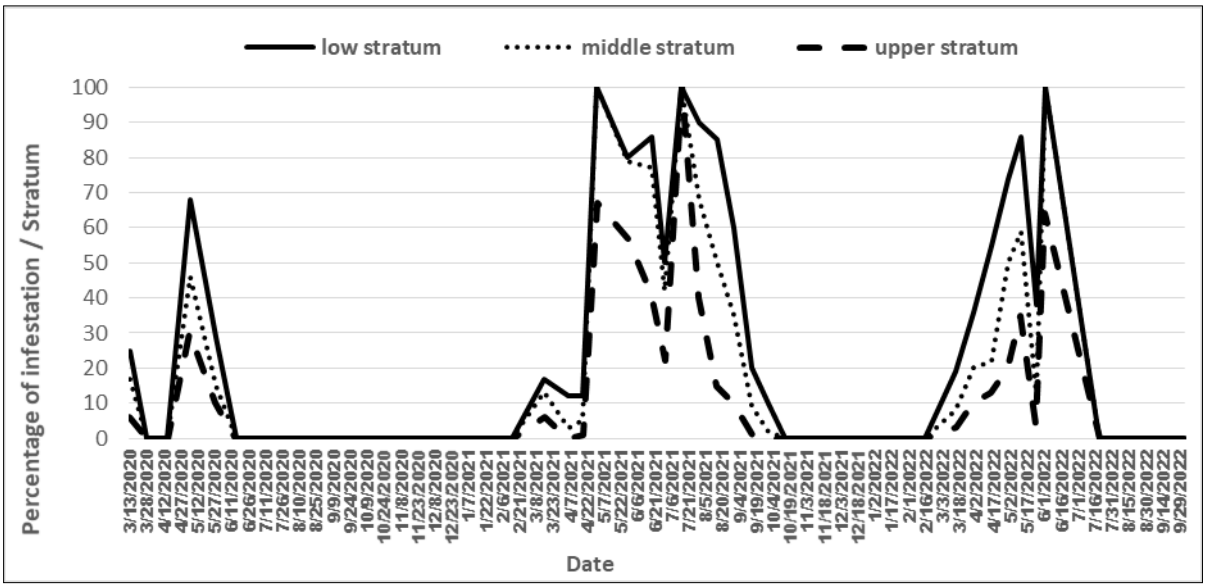

Figure 4 Evolution of the infestation of the strata of the Zephyr variety

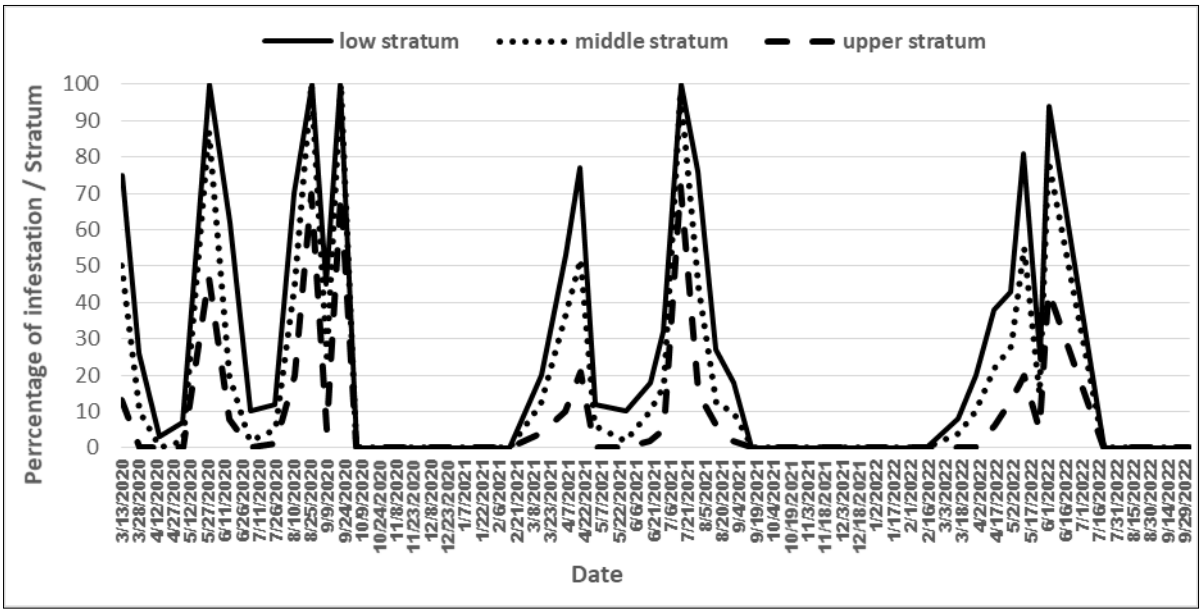

Figure 5 Evolution of the infestation of the strata of the Kaweah variety

4. Discussion

4.1. Evolution of tree colonization by *T. urticae*

Data on population dynamics show that during the three years of study, *T. urticae* outbreaks reached high densities during the peach and nectarine growing season, that is when the climatic conditions and the phenological development of the trees are favorable to the deployment of the mite. Several authors have reported that apple, pear and peach trees served as alternative hosts for *T. urticae* (Bolland et al., 1998; Slone and Croft, 2001) [8], [9].

The levels of presence of the mite estimated by the rates of infested trees, and occupied leaves, are characterized by very obvious amplitudes of variation.

The seasonal abundance of the population is one of the main characteristics required to carry out a sampling program used for the purpose of mite control or control (Pedigo and Buntin 1994) [10]. Our results showed that *T. urticae* infested the studied peach and nectarine varieties with different levels of infestation. The *T. urticae* population was initiated in mid-March, gradually increased and population peaks appeared in May, June and August and then declined later (mid-October). The first peaks of *T. urticae* infestation on the three varieties were observed in March (Rao et al.2018; Patel et al.2020) [11],[12], which is consistent with the present study. In New Zealand, Butcher et al. (1987) [13] working on strawberries reported that after the onset of *T. urticae* infestation, the mite population increased for three to four months and then declined rapidly over a short period, which is what we recorded for the untreated variety.

On the other hand, Labanowska and Chlebowska (1998) [14] recorded the highest population of *T. urticae* in June on strawberries in Poland. On soybeans in Egypt, Waheeb (1998) [15] detected the peak of *T. urticae* infestation in May, although El-Saiedy (1999) [16] noted that mite infestation was higher in April than in May. Other researchers have detected the peak of *T. urticae* infestation in spring on castor bean in Egypt (Ismail et al.2007) [17], orchids and French bean in India (Meena et al. 2013; Chauhan and Shukla 2016) [18], [19].

4.2. Within-plant distribution of *T. urticae*

Regarding the intra-plant distributions of *T. urticae* by observing all the habitable zones of the orchards studied, the results indicate that the degree of infestation varies according to the stratum, *T. urticae* is more abundant in the low and middle strata than in the upper stratum. This difference is explained by the migration of mites (for diapause) towards the ground and the herbaceous layer when the conditions are unfavorable. The end of the diapause is marked by the colonization of the lower stratum by mites (stratum closest to the ground) and from this stratum the others are contaminated. Similarly, during a chemical treatment, the first stratum affected is the upper stratum, which justifies the low percentage of infestation of this stratum compared to the others.

The characteristics of the intra-plant distribution of *T. urticae* on several hosts have already been studied. Thus [20] reported that *T. urticae* is more abundant in the lower third and absent in the upper third of rosaceae under conditions of low *T. urticae* density. However, Tollerup et al. [21] found no difference in *T. urticae* density between the upper, middle and lower strata of a peppermint plant. Onkarappa et al. (1999) [22], Mondal and Ara (2006) [23] found that mites are more abundant on the lower strata of Rosaceae. Same results were found by Fitzgerald et al. 2008 [24] on strawberry. Other studies have shown that the phenological stage of the plant also influences the distribution of *T. urticae*, the densities of adults and nymphs were highest on young strawberry leaves. However, its eggs were found more on slightly younger leaves. These results indicate that *T. urticae* could move to younger leaves to increase the survival of their offspring. This phenomenon is well known in whiteflies (Naranjo, et al, 2009)[25].

5. Conclusion

In conclusion, strong population infections were found in all the orchards studied, despite being treated with acaricides. Three causes of spider mite outbreaks have been observed: Predators of *T. urticae*, are rarely present in these Rosaceae due to the use of acaricides against mites and pests. The climatic conditions throughout the growing season are favorable to the development of the two-spotted spider mite since the irrigation is done by the drip system. Thus, precautions against spider mites should be taken when mite density peaks in late June and late September. To provide a better understanding of the reasons for mite outbreaks on peaches and nectarines, further studies are needed to determine the mode of infestation.

This study strongly suggests that pesticide applications have altered the population development and dominance pattern of spider mites in peach and nectarine orchards. In addition, the application of pesticides apparently resulted in an increase in mite populations in the three treated orchards. Moreover, the population dynamics of predatory mites seem to have changed with the application of acaricides.

Compliance with ethical standards

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Disclosure of conflict of interest

All the authors declare no conflict of interest.

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