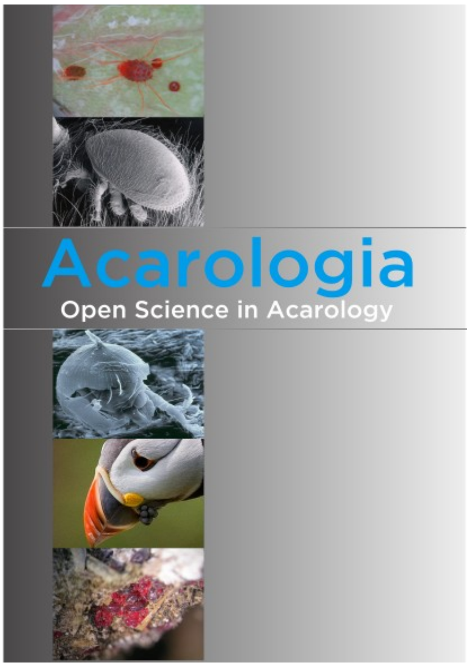

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SEASONAL POPULATION DYNAMICS OF THE TWO-SPOTTED SPIDER MITE, *TETRANYCHUS URTICAE* KOCH (ACARI: TETRANYCHIDAE) UNDER ACARICIDE CONSTRAINT ON EGGPLANT IN BURSA PROVINCE (TURKEY)

BY N. A. KUMRAL & B. KOVANCI [1]

(Accepted September 2005)

TETRANYCHUS URTICAE
POPULATION DYNAMICS
AMBLYSEIUS BICAUDATUS
INTERACTIONS
EGGPLANT

SUMMARY: The distribution and population dynamics of the Two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) were investigated in the sprayed eggplant fields of Bursa Province in the north-western region of Turkey. At 10 days interval, fifty eggplant 'cv. Yalova 49' leaves per field were removed randomly from the three commercial fields during 1999-2000. *T. urticae* was the only damaging species of Tetranychid found, and *Amblyseius bicaudus* (Wainstein) the only phytoseiid present in these fields. *A. bicaudus* abundance had significant correlation and synchrony with population densities of *T. urticae* ($P<0.05$). The activity of females of *T. urticae* was first recorded on various weeds at the end of March and February in 1999 and 2000, respectively, but the mites appeared on eggplant fields in early June and late May in the same years, respectively. The population of *T. urticae* peaked twice in both years and the first peak occurred from late June to late August and the second was observed from late September to late October. The occurrence of mites on the eggplants ended in early or mid November when the eggplant fields were mowed, although all stages of *T. urticae* were observed on these fields at this time. *T. urticae* population was positively correlated with mean temperature ($r = 0.660$ to 0.678, $P <0.05$), while negative relationship was found between mean humidity and mite population ($r = 0.653$ to 0.674, $P<0.05$).

INTRODUCTION

Turkey is one of the largest producers of eggplant in the world, ranking third in production (FAO, 2002). The eggplant, *Solanum melongena* L. is a subtropical plant which demands heat (23-26°C), and produce up to 3.5 t/da. (SENIZ, 1992). Severe attack intensity caused by Two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) result in leaves with yellowish color and reduced growth rates, flowering and yield of eggplant (BOLLAND *et al.*, 1998; LEITE *et al.*, 2003). The extensive use of acari-

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cides against the mite can have negative impact on human, environment and natural enemies, besides promoting resistance to these compounds and increasing production costs (Leite *et al.*, 2003).

Many factors such as climatic conditions and natural enemies can influence mite population on eggplant (Dent, 1995; Leite *et al.*, 2003). Several studies have reported that high temperature and non-humid climates are suitable for the development and outbreak of the two-spotted spider mite, which has two distinct peaks on eggplant annually depending on climatic conditions (Goyal, 1981; Soysal & yayla, 1987; Ho & Chen, 1992; Yasarakinci & Hincal, 2000; Leite *et al.*, 2003). One of the main hypotheses for spider mite outbreaks that occured in the recent years was the disappearance of phytoseiid mites, due to the increased use of organochlorine and organophosphate insecticides (Kreiter *et al.,* 2000). However, no information is available about the relationship between the seasonal population trends of *T. urticae* and common phytoseiid mite *Amblyseius bicaudus* (Wainstein) (Cobanoglu, 1993).

The objective of the present study was to find out the cause of mite outbreaks under acaricide stress and to establish effective and sustainable control methods on eggplant (cv. Yalova 49). We present the results of a two-year study on the population dynamics of *T. urticae*, as well as the association between weather parameters and the seasonal population trends of *T. urticae*.

Material & Methods

Mite survey. Eggplant leaves infected with the mites were collected from early June to early November from different eggplant fields of Bursa. The locations of eggplant fields were Dudakli, Narlidere, Barakfaki, Karahidir, Igdir, Hasankoy, Agakoy, Kumlukalan, Samanli, Demirtas, Derecavus, Urunlu, Gorukle, Uregil, Sahinkoy towns (Fig. 1). After collection, the leaves were examined directly under a binocular microscope. The slides of mites were made according to Helle & Sabelis (1985a). Phytoseiids were mounted between a glass slide and coverslip in Hoyer's medium after they had cleared in lactic acid at 45°C for 3 days (Kreiter & De La Bourdonnaye, 1993).

Biogeographic area and sampling sites. Bursa province is situated at northwestern Turkey, where is the main growing area for vegetable processing (Fig. 1). Generally, peach, pear, apple, olive orchards and eggplant fields are cultivated in the area, as dominant types, with numerous species of herbaceous plants in the Bursa plain which was reached from foot of the Uludag Mountain (2500 m altitude) to the Marmara Sea (Fig. 1). Due to agricultural activities, the native vegetation has been almost totally destroyed and replaced by cultivated species.

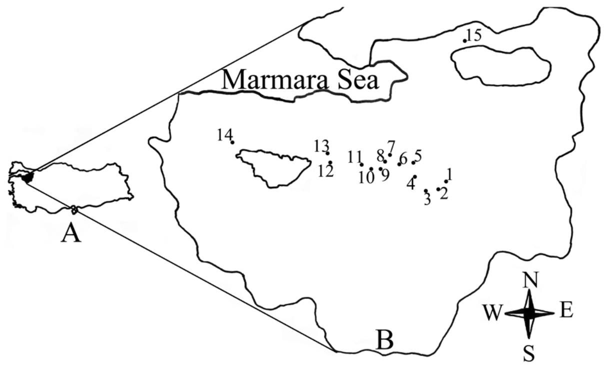

Fig. 1. Location of Bursa province in Turkey (A) and the distribution of sampling sites (B) (1, Dudakli; 2, Narlidere; 3, Barakfaki; 4, Karahidir; 5, Igdir; 6, Hasankoy; 7, Agakoy; 8, Kumlukalan; 9, Samanli; 10, Demirtas; 11, Derecavus; 12, Urunlu; 13, Gorukle; 14, Sahinkoy; 15, Uregil) used in the preliminary fields survey in Bursa.

The sampling sites were commercial eggplant fields which has 0.2 ha area, located at 20-30 km from the city of Bursa. Each sampling area was separated from the other eggplant fields by roads and peach orchards. The edge plants, commonly *Cephalaria transsylvanica* Schrad. (Dispacaceae), *Sonchus arvensis* L. (Asteraceae), *Urtica urens* L. (Urticaceae) and *Sinapsis arvensis* L. (Brassicaceae), principally, were cut or burned periodically.

Climate. Climatic data were obtained from a weather station (Hurriyet) ≈10 km west of the sampling areas. At the sampling period, from the end of May to the early November, the total rainfalls were 223.1 mm and 244.3 mm, the average relative humidity were 60% and 58.9% and the average temperatures were 22°C and 21.3°C in 1999 and 2000, respectively.

Chemical treatments. All eggplant fields were sprayed with an insecticide (chlorpyriphos-ethyl) against *Leptinotarsa decemlineata* (Say) when eggplant seedlings were transplanted on fields. Different acaricides were traditionally sprayed by producers after eggplant leaves spotted intensively by spider mites at these fields in both years: 5% fenpyroximate (0.75ml/l water) at Dudakli, 50% bromopropylate (1ml/l water) at Narlidere and 20% tebufenpyrad (0.75ml/l water) at Igdir.

Mite sampling. The samples were taken from three commercial eggplant fields, Dudakli, Narlidere and Igdir, infested by *T. urticae* in 1999-2000. In the both years, fifty leaves were collected randomly in each eggplant field at 10-days intervals from late May, when eggplant seedlings were transplanted, to early November when the fields were plant-plowing. Leaves were put into vinyl bags and held in an ice-chilled cooler. Laboratory observations were conducted using a binocular microscope. Each stage of *T. urticae* and predatory mites were counted by using 20 cm^2 area cards within a day. Abundance was calculated for each field [abundance: the number of mites or eggs per leaf (20 cm^2 area) at each sampling date].

Statistical analysis. The statistical variation in mite abundance between years and locations were analyzed using a one-way analysis of variance (ANOVA), following a mean separation a Student-Newman-Keuls test (SAS Institute, 2002). In addition, mite abundance data were analyzed in relation to some weather parameters (mean temperatures, mean relative humidity and total rainfall) and phytoseiid mite density.

Results

The distribution of Tetranychus urticae in eggplant fields

Field studies showed that *T. urticae* occurred in either low or high numbers in the eggplant growing towns of Bursa. Distribution of *T. urticae* in Bursa is showed below:

Kestel (Bursa): Dudakli (40.215°N, 29.315°E), 16 June 1999, 10♀; 26 June 1999, 5♂,5♀; 24 July 1999, 2♀; 4 Aug 1999, ♂; 4 Nov 1999, ♀; Narlidere (40.220°N, 29.299°E), 26 June 1999, 3♀, 3♂; Barakfaki (40.233°N, 29.275°E), 24 July 1999, 5♀, ♂; Gursu (Bursa): Karahidir (40.246°N, 29,239°E), 16 June 1999, 5♀, ♂; 14 Oct 1999, 2♀; Igdir (40.255°N, 29.187°E), 26 June 1999, 2♀, ♂; 14 Oct 1999, ♀, ♂; Hasankoy (40.237°N, 29.188°E), 4 July 1999 5♀, ♂; 4 Aug 1999, 7♀, ♂; Agakoy (40.248°N, 29.176°E), 24 Sep 1999, 2♀, ♂; Kumlukalan (40.241°N, 29.157°E), 16 June 1999, ♀, ♂, 26 June 1999, 5♀, 2♂; 4 July 1999 5♀, 5 ♂; Osmangazi (Bursa), Samanli (40.238°N, 29.123°E), 16 June 1999, 5♀, ♂, 4 July 1999 5♀, ♂; Demirtas (40.239°N, 29.079°E), 26 June 1999, 2♀, ♂; 4 Aug 1999, 5♀, ♂; Derecavus (40.279°N, 29.014°E), 4 July 1999, 5♀, 3♂; Nilufer (Bursa): Urunlu (40.202°N, 28.882°E), 4 Aug 1999, 5♀, 5♂; 10 Aug 2000, 2♀, 2♂; Gorukle campus (40.224°N, 28.863°E), 12 July 2000, 4♀, 3♂; Karacabey (Bursa): Sahinkoy, May-Tarim fields (40.227°N, 28.339°E), 15 July 2000 ♀, ♂; Orhangazi, Uregil (40.506°N, 29.394°E), 10 Aug 2000, 3♀, 2♂, leg. N.A.Kumral, Uludag University Collection.

The population dynamics of T. urticae. The first *T. urticae* emerged on various weeds, especially *C. transsylvanica,* and pear, peach and apple trees at the end of March and February in 1999 and 2000, respectively, but the mites were determined at sampled eggplant fields in Bursa on early June and late May in 1999 and 2000, respectively (Fig. 2).

Seasonal dynamics of *T. urticae* are shown separately for each sampling field in Fig. 2. The first females emerged on June 16 in Narlidere and on June 26 in Dudakli and Igdir in 1999. In 2000, female emerged 6 days earlier in Dudakli, 4 days later in Narlidere and 16 days earlier in Igdir compared with 1999 (Fig. 2). On the other hand, the population fluctuations of immature stages and the production of the eggs were similar to females in both years.

In this study, no statistically significant difference was found at Dudakli ($F=0.93$, $df=1,30$, $P>0.05$), Narlidere ($F=2.66$, $df=1,30$, $P>0.05$) and Igdir ($F=0.001$, $df=1,20$, $P>0.05$), when means of the mite abundance were compared in terms of years. Similarly, the total rainfalls ($F=0.03$, $df=1,30$, $P>0.05$), the average relative humidity ($F=0.11$, $df=1,30$, $P>0.05$) and the average temperatures ($F=0.21$, $df=1,30$, $P>0.05$) did not show any significant differences between 1999 and 2000. But, as seen at Fig. 2, the population fluctuation pattern varied from year to year. The first year showed the highest population density on 14-24 August, when the average tempera

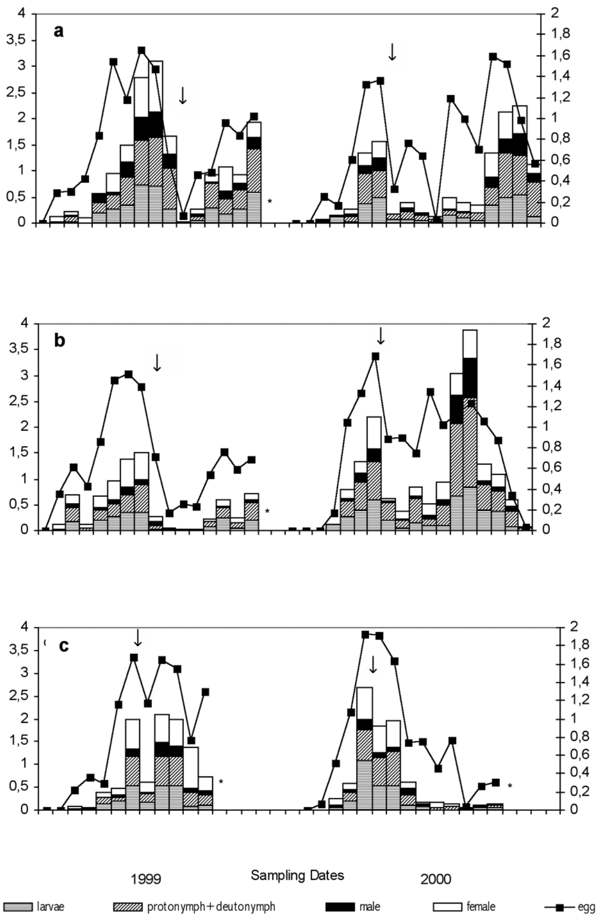

FIG. 2. Seasonal population fluctuations of egg, immature and mature stages of *Tetranychus urticae* in Dudakli (a), Narlidere (b) and Igdir (c) eggplant fields of Bursa in 1999 and 2000. ↓: spraying with acaricides; *: plant-plowing.

tures and the average relative humidity were 28°C and 65%, respectively. Due to the rainy weather conditions and the low temperatures, the population decreased, followed by a new peak in early November except for Igdir (early plowing). In subsequent days the Dudakli and Narlidere eggplant fields were plowed by producers.

In the second year, the population density of *T. urticae* started to increase in late June and peaked on July 20 when the average temperatures and relative humidity were 29°C and 48%, respectively. Probably, due to acaracide treatment in Igdir, on June 30, the population increase was inhibited and an early peak was occurred. In all fields, the abundance fell rapidly in early August because of acaricide treatment, 20 mm rainfall and the low temperatures. Thereafter, the population density of *T. urticae* fluctuated belong to the total rainfall on August 30, September 20 and October 10 (40, 30 and 65 mm, respectively) and in this period, it reached a peak on September 30 in Narlidere and on October 30 in Dudakli.

Statistical analysis showed that *T. urticae* reached significantly higher population densities in Dudakli (4.97 individuals/leaf) than those in Narlidere (1.59 individuals/leaf) and Igdir (2.78 individuals/leaf) only in 1999, probably, because of delayed acaricide treatment in Dudakli (F=4.025, df= 1,30, P=0.05).

According to the results of statistical analysis, mean temperature (r = 0.660 to 0.678, P <0.05) showed a positive association with mite abundance. Mean humidity in general was negatively correlated with mite abundance (r = 0.653 to 0.674, P<0.05). An important association was not found between rainfall and the mite trends.

The occurrence of mites on the eggplants ended in early November when the eggplant fields were plant-plowing, although all stages of *T. urticae* were observed on some fields at this time. Abundance of diapausing females, had orange body color, were also observed to increase on eggplant leaves before plant-plowing when the low temperatures under 11h > day-length. In all populations, 9.5 ± 4.8% and 2.7 ± 0% diapausing females appeared in mid October and the percentage of mites undergo reproductive diapause reached 47.2 ± 19.6% and 53.5 ± 18.7% in early November in 1999 and 2000, respectively.

Predator mites. Three predator mites were recorded in this survey. *Amblyseius bicaudus* (Wainstein), (Acarina: Phytoseiidae) is one of the most important predator mite on eggplants in Bursa. Due to low predator mite density, the population trend of *A. bicaudus* can not be determined in 1999. In 2000, this species, like *T. urticae*, was particularly abundant in July, August and October. Being emerged at early June, *A. bicaudus* reached the highest population on August 20 at Dudakli field (FIG. 3a). On the other hand, the first *A. bicaudus* in Narlidere emerged 10 days later compared to Dudakli. The number of the predators increased 17 times from July 10 to September 30 and showed three peaks in this field (FIG. 3b). Activity of predator mite continued until October 10 and November 10 in both fields, respectively. As seen

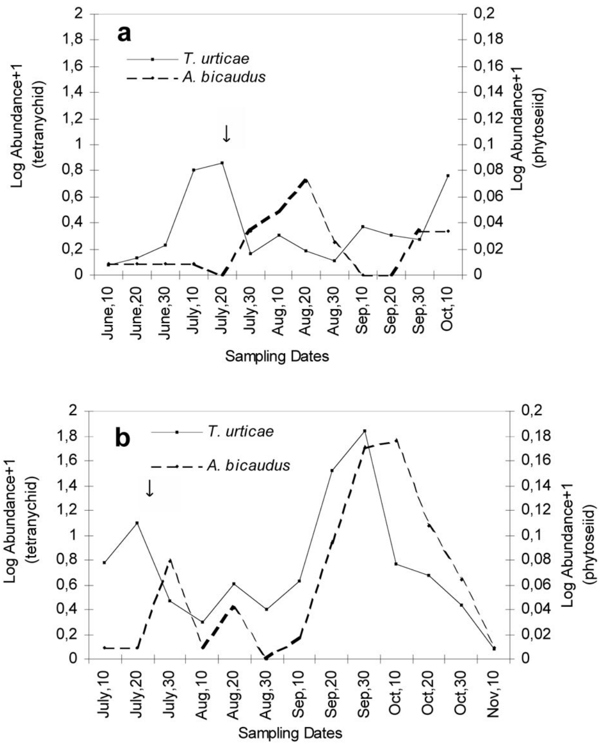

FIG. 3. — Population fluctuations of *Amblyseius bicaudus* and all active stages of *Tetranychus urticae* in Dudakli (a), and Narlidere (b) eggplant fields of Bursa in 2000.
↓: spraying with acaricides; *: plant-plowing.

clearly at FIG. 3b, the species showed a strong response to the *T. urticae* population fluctuations, especially at Narlidere. However, the predator mite abundance (r = 0.248 to 0.580, $P<0.05$) showed a positive association with abundance of mature and immature stages of *T. urticae*, but no association was found between the number of eggs of *T. urticae* in both fields (FIG. 3b). Predator mites from other families, i.e. Tydeidae [*Pronematus ubiquitus* (McGregor) and *Tydeus* sp.] and Stigmaeiidae, were also determined, but they represented a very minor proportion of all mites inventoried (less than 0.06 individual/leaf).

DISCUSSION

Our results showed that *T. urticae* was the only damaging mite species, due to the increasing pesticide use on eggplant in Bursa. Increased use of pesticides has been shown to change species composition, decrease species diversity, and cause outbreaks of spider mites such as *T. urticae* and *T. cinnabarinus* (Boisduval) on eggplant (GOYAL, 1981; LISS *et al.,* 1986; SOYSAL & YAYLA, 1987; HO & CHEN, 1992; DHAMDHERE *et al.*, 1995; BOSTANIAN *et al.* 2003). Also, *T. urticae* were observed on pear, apple and peach trees until eggplant seedlings were transplanted on fields. Several authors have reported that apple, pear and peach trees served as alternative host plants for *T. urticae* (DUZGUNES, 1954; BOLLAND *et al.*, 1998; SLONE & CROFT, 2001).

In this study, the peak of population density showed one type of the seasonal dynamics of *T. urticae*, i.e. bi-peak, in consistent with periods of chemical control. Two peaks of population trends in *T. urticae* occurred from late June to late August and from late September to late October. Second peak emergence after chemical control stress as well as high rainfall period; may be called as 'resurgence', which occurred in eggplant fields, e.g. Dudakli and Narlidere (FIG. 2). This result is in agreement with those of SOYSAL & YAYLA (1987) and HO & CHEN (1992) who reported bi-peak emergence pattern of *T. urticae* on eggplants in Turkey and Taiwan. Also, differences in the population fluctuation pattern of *T. urticae* between 1999 and 2000 could be related to the highest temperature occurred earlier in 2000 than 1999 together with the high rainfall level in 2000.

Based on the relationship between weather parameters and the seasonal population abundance of *T. urticae*, increasing mean temperature and decreasing mean relative humidity stimulated population increase of *T. urticae.* In addition, the hot climate or intensive rainfall directly influenced the mite density. FUJIMOTO & TAKAFUJI (1986) reported that photoperiod length and temperature are closely related to mite population increases. Studies on *T. urticae* life tables revealed faster development of this mite as a direct response to increasing temperature (DUZGUNES & COBANOGLU, 1983; MARGOLIES & WRENSCH, 1996). HELLE & SABELIS (1985a) revealed negative effect of high humidity on the survival of the active stages of phytophagous mites, which can tolerate 60-80% R.H. They noted that level of rainfall and quality of host plants were key factors in regulating seasonal population dynamics of *T. urticae*. A combination of all these factors mentioned above certainly influences *T. urticae* populations. Consequently, summer outbreaks are most likely to occur in summer conditions in area with a temperate climate.

In both years, the diapausing females of *T. urticae* started to appear on eggplant leaves in mid October when the average temperatures reached 11-12°C under a daylength of 11h. Several authors have found that *T. urticae* undergo reproductive diapause induced by short-days (the critical nightlength is 10.5 h) and low temperatures (15°C) as in several *Tetranychus* species (HELLE, 1962; VEERMAN, 1977; TAKAFUJI *et al.,* 1991). According to VEERMAN (1977), although photoperiod was shown to be predominant factor for the regulation of diapause in the *T. urticae,* other environmental variables such as temperature and food also exert an influence.

Experimental fields generally had low populations of *A. bicaudus*, with very high *T. urticae* densities. The fluctuation pattern of the phytoseiid mite showed a few similarities to *T. urticae* dynamics in Dudakli, whereas the abundance of the species in Narlidere was synchronized with the abundance of *T. urticae.* We are not sure of the causes of such differences, but it may be use of different acaricides or chlorpyriphos-ethyl in early season. *A. bicaudus* is very common on herbaceous plants in apple orchards of Turkey (COBANOGLU, 1993), on grapevines in France (KREITER *et al*., 2000), on grasses and *Fragaria* spp. in Latvia (SALMANE & PETROVA, 2002). Several families of non-phytoseiid acarines contain spider mite predators, of which the Stigmaeidae are the most important. Tydeids are very common on plants, where they feed on Homopteran honeydew and resultant sooty-mold fungi, on other epiphytes, pollen and various plant debris. BRICKHILL (1958) offered an exclusive diet of *Panonychus ulmi* Koch and *T. urticae* eggs to 2 tydeid species. A predator of eriophyoid mites was determined as *P. ubiquitus* on the tomato in Izmir (Turkey) and Egypt (YASARAKINCI & HINCAL, 1997; ABOU-AWAD *et al*., 1999). But, the presence of mites of uncertain feeding habits (e.g. Tydeidae) in spider mite populations does not necessarily effect on feeding on the pests (HELLE & SABELIS, 1985b).

In conclusion, heavy infections and high populations were found in all experimental eggplant fields, although they were sprayed with acaricides. Three causes of spider mite outbreaks were observed: (1) *A. bicaudus,* which may be an important predatory mite of *T. urticae,* disappeared or rarely present in these fields due to the indiscriminate and unnecessary use of pesticides against spider mites and insect pests. (2) Acaricides were sprayed after eggplant leaves were spotted intensively by spider mites in these fields. (3) The climatic conditions throughout growing season are favourable for the development of the two-spotted spider mite. Thus, precautions against spider mites must be taken when the mite density reached a peak in late June and late September. To provide a better understanding of the reasons of mite outbreaks on eggplant in Bursa, further studies are needed to determine feeding preference and capacity of *A. bicaudus* and to establish the relationship between predacious insects (chrysopids, coccinellids, heteropters, thysanopters etc.) and *T. urticae* abundance.

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