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Oligonychus afrasiaticus (Acarina: Tetranychidae). Seasonal Abundance and Life History of the Old World Mite on Various Date Palm Cultivars in Segdoud Oasis, South Tunisia

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ABSTRACT

We compared the susceptibility of four Tunisian cultivars of date palm, *Phoenix dactylifera*, to feeding by *Oligonychus afrasiaticus* based on the seasonal abundance of spider mites in 2006 and 2007 in Segdoud oasis, south Tunisia. Cultivars were categorized into three groups: 'Deglet Noor' and 'Alig' were susceptible, 'Kentichi' was resistant and 'Bessr' was of an intermediate susceptibility. A life table study in the laboratory showed that at 32°C, *O. afrasiaticus* feeding on 'Bessr' illustrated the lowest intrinsic rate of natural population increase (r_m = 0.136 day^{-1}). Their virulence was low because of low fecundity and reduction in fertility. Reared on 'Deglet Noor' fruits, *O. afrasiaticus* presented the highest demogaphic intrinsic rate of natural population increase (r_m =0.213), proving that this cultivar's dates are more susceptible to attack by this mite.

Keywords: 'Alig', 'Bessr', 'Deglet Noor' , 'Kentichi'

INTRODUCTION

Tunisia is considered to be one of the major date-producing countries. The number of palm trees is estimated to be over 4 million with around 110,000 tons of dates produced annually. Variety 'Deglet Noor' accounts for 60% of total production (FAOSTAT 2005).

The old world date mite, *Oligonychus afrasiaticus* (McGregor), is one of the four major pests of date palms in Tunisia (Dhouibi 1991; Khoualdia *et al*. 1997). When present, it can cause very serious damage to fruits (Dhouibi 1991).

O. afrasiaticus is present in all date-growing areas: Mauritania (Caudin and Galvez 1976), Algeria (Guessoum 1986), Libya (Edongali *et al*. 1988), Egypt (Saleh and Hosny 1979), Tunisia (Dhouibi 1991), Saudi Arabia (Talhouk 1991), Oman (Elwan 2000), Iraq (Hussain 1969), Jordan (Palevsky *et al*. 2004), Israel (Palevsky *et al*. 2003), Iran (Kadjbaf Vala and Kamali 1993) and Yemen (Baankoud and Basahih 2000).

The infestation of *O. afrasiaticus* begins and increases in summer and decreases in autumn. During this period, dates mature through four stages during which color, flavor and texture change. The first stage "Kimri" is an inedible green fruit which then develops into a yellow glossy stage called "Khalal", then to a soft brown stage early ripe named "Rutab". The final stage, dark brown and fully ripe, is known as "Tamar" (Dowson and Aten 1962).

The "Kimri" stage is characterised by the green colour of fruit, a rapid increase in size, weight, and reducing sugars (Barreveld 1993). Feeding on immature green dates by *O. afrasiaticus* causes severe fruit scarring and a reddish-brown appearance.

Mite populations begin to decline with colour change of fruit to yellow or red at the "Khalal" stage, when the weight gain is slow but sucrose content increases, moisture content goes down, and tannins start to precipitate and lose their astringency (Ben Chaaban and Chermiti 2009).

Differences in development, reproduction, fertility, longevity and population development of Tetranychid mites on different host plants are common. These differences may be associated with impediments to feeding such as host plant texture, nutritional value of the host plant, host physiology (Bengston 1970; Helle and Sabelis 1985; Archer *et al*. 1986; Kielkiewicz and Van de Vrie 1990; Kerguelen and Hoddle 2000; Kasap 2003; Ragusa and Ferragut 2005; Kafil *et al.* 2007; Razmjou *et al*. 2008; Vásquez *et al*. 2008).

The aim of this study was to compare the susceptibility of four date palm cultivars to *O. afrasiaticus* mite by (i) quantifying date damage on these cultivars from field-collected samples, and (ii) quantifying demographic parameters of *O. afrasiaticus* in the laboratory on "susceptible" and "resistant" cultivars identified.

MATERIALS AND METHODS

Cultivar susceptibility to *O. afrasiaticus*

The susceptibility of four date palm cultivars to *O. afrasiaticus* was assessed by counting motile stages on dates collected from date palms grown in a single plot of mixed cultivars in Segdoud (southern Tunisia).

During 2006 and 2007 seasons, 10 palm trees from each of four cultivars: 'Deglet Noor', 'Alig', 'Bessr' and 'Kentichi' were picked. 10 dates from each tree were randomly sampled every week. The upper parts of palm trees were sprayed with sulphur on July 2nd, July 24th and August 1st in 2006 and on July 13th, July 28th and August 5th in 2007, concentrated at 10-15 g/L with l0 L of mixture per tree.

Mite development and life table construction

1. Mite cultures

O. afrasiaticus was collected from 'Deglet Noor' variety date fruits in Segdoud near Tozeur (southern Tunisia) in July 2006 and maintained in the laboratory on sorghum plants (*Sorghum bicolor*) at 25 ± 1°C, 50-75% RH and a 16-h photoperiod (8000 lux).

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Original Research Paper

2. Experimental conditions

Experiments were conducted on date fruits of the four date palm cultivars. Date fruits were collected during the "Kimri" stage, characterised by the green colour of fruits from trees grown in a single plot of mixed cultivars in Segdoud near Tozeur (southern Tunisia).

All the experiments were conducted in a climate-controlled chamber at 32 ± 1°C, 60 ± 10% R.H. and a 16-h (8 000 lux) photoperiod. Date fruits were placed on a water-saturated foam mat in a plastic tray. The wet cotton wool prevented mite escape and maintained freshness of date fruits for two weeks. The cotton wool was maintained wet by adding water when necessary.

3. Survival rate and development

Juvenile survival and development duration of *O. afrasiaticus* males and females was determined by the placement of 50 inseminated adult females taken from the stock culture on date fruits. The females were allowed to lay eggs, and removed after 1 h. This operation was repeated until obtaining 100 eggs. After hatching, larvae were reared on fresh experimental units. The developmental stages were observed at 12-h intervals until they reached maturity.

4. Oviposition

One female teliochrysalid and two males were placed on each date fruit. The males were removed 48 h after female emergence. This experiment was replicated 50 times for each cultivar.

In order to evaluate female fertility, dates were checked daily and the number of laid and hatched eggs on each support were recorded until the death of all females. When fruits started to deteriorate, mites were moved to healthy ones.

5. Sex-ratio

The sex-ratio is defined as the proportion of females in the progeny. The method was the same as that used for oviposition, except that only 20 females were placed individually on date fruits. After oviposition, dates with eggs were maintained under the same experimental conditions as for females. The sex-ratio was determined by counting adults originating from those eggs. Non-mated females, i.e. producing only males, were not considered.

6. Demographic parameters

A life table was constructed considering the female cohorts studied. The net reproductive rate (*Ro*), the mean generation time (*T*), the intrinsic rate of natural increase (r_m), the doubling time (*Dt*), and the finite rate of increase (λ) were calculated using the method recommended by Birch (1948):

$$1 = \sum_{X=0}^{K} e^{-r_m x} (l_x m_x)$$

With x = pivotal age, lx = number surviving to age x, m_x = age-specific fecundity

- $Ro = \Sigma\ lx\ mx$
- $r_m = \ln(Ro)/ T$
- $Dt = \ln 2 / r_m$
- $T = \ln Ro / r_m$
- $\lambda = e^{-rm}$

Statistical analysis

Data on developmental time, duration of female reproductive periods and fecundity were analyzed using one-way ANOVA followed by Sheffe's test ($P = 0.01$) to compare data means. Differences in sex-ratio were analyzed by the Chi-squared test.

RESULTS

Cultivar susceptibility to *O. afrasiaticus*

O. afrasiaticus infestation began and increased during the "Kimri" stage, which is characterised by the green colour of fruit.

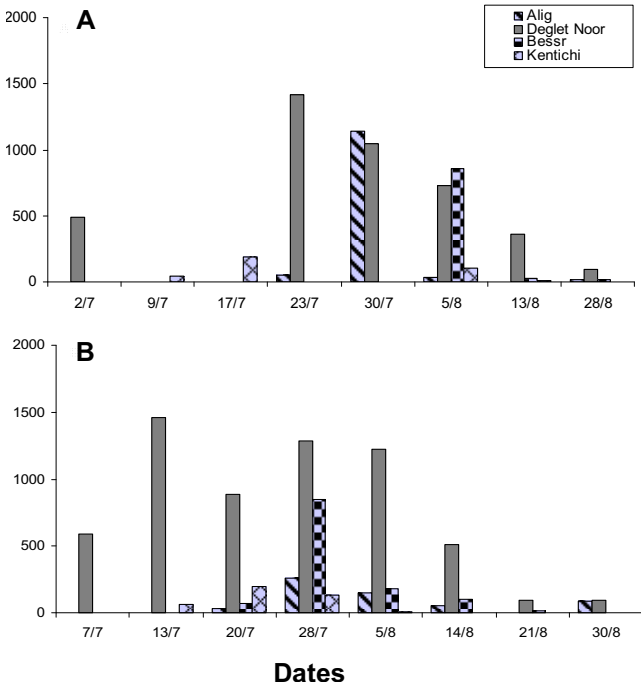

Fig. 1 Densities of *Oligonychus afrasiaticus* motile stages, at Segdoud, South of Tunisia. (**A**) 2006 (**B**) 2007, on date cultivars 'Deglet Noor', 'Alig', 'Bessr', and 'Kentichi'.

During 2006-2007, *O. afrasiaticus* on 'Deglet Noor' fruits was consistently first observed in the beginning of July. Populations increased during July and August; levels of *O. afrasiaticus* exceeded 1460 mites per 100 dates in the second week of July in 2006. These densities persisted until the end of August in 2006 and 2007 (**Fig. 1**).

On 'Alig' dates, mites were first observed in the fourth and third week of July in 2006 and 2007, respectively. Populations did not increase until early August, peaking at 1138 and 1052 mites per 100 fruits in the fourth week of July in 2006 and 2007, respectively. Mite densities persisted until the end of August in 2006 and 2007.

On 'Bessr', the initiation of infestation varied between years, ranging from the second half of July to the beginning of August, and populations levels peaked at about 860 motile forms per 100 fruits in 2006. Mites living on 'Bessr' dates until the first half of August were absent since the third week of the same month in 2007.

O. afrasiaticus motile stages were found on 'Kentichi' fruits from the second week of July until the first week of August in 2006 and until the fourth week of July in 2007. Low mite populations were observed on 'Kentichi' fruit; maximum motile stages registered did not exceed 193 per 100 dates in 2006 and 2007. The number of *O. afrasiaticus* motile stages on dates was significantly different among cultivars. We can categorize it as low on 'Kentichi' fruits and high on 'Deglet Noor' and 'Alig' fruits. Damage was intermediate on 'Bessr' dates.

Mite development and life table construction

1. Immature development

The total developmental time (egg-adult) of *O. afrasiaticus* females showed significant differences among date fruit cultivars ($P = 0.000$, df = 3, $F = 125.7$). *O. afrasiaticus* females developed faster on 'Deglet Noor' and 'Alig' than on 'Kentichi'. Females developed slowly on 'Bessr' (**Table 1**). Males developed faster on 'Deglet Noor' and slower on 'Bessr' (Sheffe's test, $P < 0.01$) (**Table 1**).

Total development duration was significantly longer in females than in males on all feeding supports (Sheffe's test, $P < 0.01$) (**Table 1**).

Table 1 Mean (± SD) in days of the development duration of females and males of *O. afrasiaticus* at 32°C on different palm dates cultivars and immature survival.

Stage	Alimentary support				
	Deglet Noor	**Alig**	**Kentichi**	**Bessr**	***P*<*F* $_{(df1, df2)}$ (α = 0.01)**
Number of eggs tested *N*	100	100	100	100	
♂	25	24	23	17	
♀	67	64	58	58	
Duration days					
♂	7.5 (0.5) a	7.7 (0.2) a	7.9 (0.4) a	8.4 (0.6) b	$P< F_{(3, 85)} = 16.9$
♀	8.2 (0.5) a	8.3 (0.3) a	9 (0.3) b	9.5 (0.6) c	$P< F_{(3, 243)} = 125.7$
Immature survival (%)	92	88	81	75	

Means in a row followed by same letter are not statistically different (Sheffe's test, $P < 0.01$).

Table 2 Mean (± SD) of adult phases, longevity ovipositional rates and hatchability of *O. afrasiaticus* at 32°C on different palm dates cultivars, number of replicates (*N*).

Stage	Alimentary support				
	Deglet Noor	**Alig**	**Kentichi**	**Bessr**	***P*<*F* $_{(df1, df2)}$ (α = 0.01)**
Pre-oviposition in days	0.9 (0.8) a	1.1 (0.5) a	0.7 (0.9) a	0.9 (0.8) a	$P< F_{(3,196)} = 1.5$
Oviposition in days	8 (3.3) a	6.8 (2.7) a	6.3 (2.5) a	6.4 (2.9) a	$P< F_{(3,196)} = 3.8$
Post-oviposition in days	1.5 (0.9) a	1.3 (0.7) a	1.3 (1) a	1.5 (0.9) a	$P< F_{(3, 196)} = 0.6$
Longevity in days	10.4 (2.9) a	9.2 (2.8) ab	8.4 (2.4) b	8.8 (2.8) ab	$P< F_{(3, 196)} = 4.9$
Total eggs per female	18.7 (6.7) a	10.4 (3.9) b	10.5 (5.4) b	10.1 (5.4) b	$P< F_{(3, 196)} = 28.6$
Eggs per female per day	1.7 (0.7)	1 (0.3)	1.1 (0.5)	1 (0.5)	
Fertility	94	92.7	93.3	90.2	
Sex ratio	0.76 a^1	0.74 a^1	0.74 a^1	0.73 a^1	
N	50	50	50	50	

Means in a row followed by same letter are not statistically different (Sheffe's test, $P < 0.01$).
Values in a row followed by a^1 are not statistically different (χ^2, $P > 0.05$)

The immature survival rate ranged from 92 to 75%. The immature survival rate (**Table 1**) was highest on 'Deglet Noor' (94%).

2. Reproduction

Female longevity of *O. afrasiaticus* was affected by date palm cultivar: females lived longest on 'Deglet Noor' (10.4 days) and shortest on 'Kentichi' (8.4 days) (**Table 2**).

There were no significant differences between female fecundity of *O. afrasiaticus* reared on 'Alig', 'Kentichi', and 'Bessr', 10.4, 10.5 and 10.1 eggs/female, respectively. The total number of eggs laid per female was significantly higher (Sheffe's test, $P < 0.01$ (**Table 2**)) on 'Deglet Noor' fruits (18.7 eggs/female).

The daily egg production per female among varieties was categorized as low on 'Alig', 'Kentichi'and 'Bessr' and high on 'Deglet Noor' fruits (1.7 eggs/female).

Daily egg production (eggs/female/day) reached a peak on the 12th day (2.54), the 15th day (1.65), the 15th day (1.46) and on the 13th (1.54) on 'Deglet Noor', 'Alig', 'Bessr' and 'Kentichi', respectively, and it decreased gradually thereafter for all cultivars (**Fig. 2**).

The oviposition period was longer on 'Deglet Noor' than on other cultivars (Sheffe's test, $P < 0.01$) (**Table 2**).

There were no significant effects of plant-based foods on the sex-ratio of *O. afrasiaticus* descendant (χ^2, $P > 0.05$) (**Table 2**); the sex-ratio is always female biased.

No significant differences in fertility were observed between the different plant-based food resources. The lowest fertility was observed on'Kentichi' dates (92.8%).

3. Life table

Calculated life table parameters are given in **Table 3**. The longest mean generation time (*T*) occurred on 'Bessr' (14.7 days), followed by 'Kentichi' and 'Alig' whereas the shortest mean generation time was determined on 'Deglet Noor' fruits (13.2 days). Net reproductive rate (*Ro*) was highest on 'Deglet Noor' fruits (16.5 females/female). Concurrent with the tendency observed for lowest duration of development and with the higher rates observed of oviposition, the mites reared on 'Deglet Noor' fruits present the highest values of the intrinsic rate of natural increase successively $r_m = 0.213$ day^{-1} while mites on 'Bessr' had the lowest intrinsic rate of increase ($r_m = 0.136$). Consequently, feeding on 'Deglet Noor' fruits engenders the shortest doubling time ($Dt = 3.3$ days) of mites.

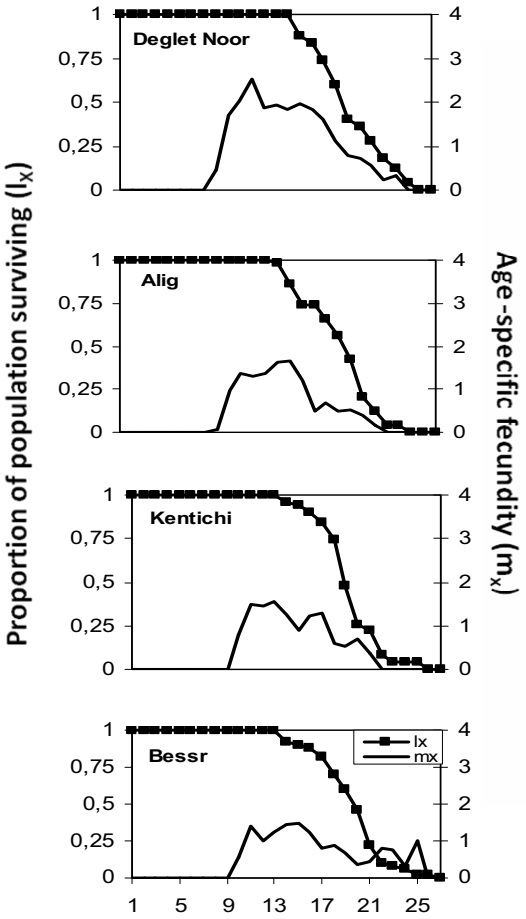

Fig. 2 Survivorship curve (l_X) and age-specific fecundity (m_x) of *O. afrasiaticus* on palm date cultivars at 32°C.

Table 3 Demographic parameter of *O. afrasiaticus* at 32°C on for palm date cultivars at Segdoud oasis, South of Tunisia: net reproductive rate (Ro), mean generation time (T), intrinsic rate of increase (r_m), doubling time (D_t) and finite rate of increase (λ).

Alimentary support	Ro	T	λ	D_t	r_m
Deglet Noor	16.5	13.2	1.24	3.3	0.213
Alig	9.2	14.3	1.17	4.5	0.155
Kentichi	8.5	14.5	1.16	4.7	0.148
Bessr	7.4	14.7	1.15	5.1	0.136

DISCUSSION

Cultivar susceptibility to *O. afrasiaticus*

Comparison of seasonal fluctuation of selected palm dates cultivars showed significant and quantifiable differences in susceptibility to *O. afrasiaticus* feeding. 'Deglet Noor' appeared to be very susceptible and suffered the most from *O. afrasiaticus* infestation. Infestations occurred early in the season at the beginning of July. On 'Deglet Noor' in Segdoud mite populations were present from July until September. Colonization of the other date cultivars by this mite occurred late until the second week of July. Infestation stress was intermediate on 'Alig' while 'Bessr' and 'Kentichi' were more resistant. Maximum *O. afrasiaticus* motile forms on 'Deglet Noor' dates were approximately 1.7 and 7.5 times more abundant than on 'Bessr' and 'Kentichi', respectively.

Depending on fluctuation of climatic conditions from year to year the intensity of infestation changes. Mite populations were seen on 'Deglet Noor' dates for 8 weeks, on 'Alig' dates for 2 to 5 weeks, and for 2 to 4 weeks on both 'Kentichi' and 'Bessr'.

In Segdoud, infestation started in the first three weeks of July, and increased rapidly during August.

The monthly mean temperature of July and August in Segdoud was about 32°C, which coincides with dispersal peak and activity of *O. afrasiaticus* populations.

Differences in susceptibility of date palm varieties to *O. afrasiaticus* have been reported from several areas. The Iraqi variety 'Sayer' was relatively resistant to mite attack (Hussain 1974). In Libya, the varieties 'Asabir', 'Aurig', 'Bestian', 'Apel' and 'Talise' were found to be most susceptible while 'Tafsirt' was found to be less susceptible (Edongali *et al*. 1988). Cultivars 'Hilali', 'Gibri' and 'Khanazani' in Oman were infested by *O. afrasiaticus* during the month of April, whereas other cultivars were attacked later in the season (Elwan 2000). In Israel, Palevsky *et al*. (2005) reported that 'Deglet Noor' was attacked more than 'Medjool' and 'Barhi'. In the Kingdom of Saudi Arabia, date fruit cultivars 'Sokary' and 'Rothan' appeared highly susceptible to *O. afrasiaticus* infestation. However, cv. 'Cebiky' seemed to be resistant, while 'Khodary' appeared to have moderate resistance to infestation by this mite species.

Mite development and life table construction

Laboratory studies showed that at 32°C female longevity, fecundity, fertility and immature survival were significantly higher on 'Deglet Noor' dates. When *O. afrasiaticus* fed on 'Alig', 'Bessr' and 'Kentichi' dates, a significant increase in development duration and a reduction in fecundity were recorded. The resultant low capacity of population growth suggests poor demographic performance of *O. afrasiaticus* on these cultivars.

Based on the r_m values, 'Deglet Noor' was the most favourable feeding support (r_m = 0.213) and 'Bessr' was the least suitable variety for *O. afrasiaticus* (r_m = 0.136). The intrinsic rate of natural increase (r_m) is an important parameter for describing the growth potential of a population under specific climatic and food conditions because it reflects the overall effects of temperature and food on development, reproduction and survival (Southwood 1978). The r_m values of Tetranychidae under favourable conditions were above 0.2 days (Sabelis 1991). This variation in r_m was mainly caused by differences in developmental time of the spider mites (Margolis and Wrensch 1996; Krips *et al*. 1998).

O. afrasiaticus, reared at 30 ± 1 and 38 ± 1°C, presented higher performance on dates than on *Sorghum* sp. leaves (Kadjbaf *et al.* 1993). The mean generation time was estimated at 11.2 and 8.8 days, respectively at 30 and 38°C. Under the same conditions total eggs produced by females were 58 (1-7 days) and 38 (2-5 days), respectively at 30 and 38°C (Kadjbaf *et al.* 1993).

Tetranychids pierce the parenchyma tissue of leaves with their stylets and siphon out the cells' contents (Jeppson *et al*. 1975; Van der Geest 1985). Consequently, mite nutrition is directly affected by the chemical composition of ingested fluids. The present results suggest that the observed differences between the susceptibility of 'Deglet Noor', 'Kentichi', 'Alig' and 'Bessr' to *O. afrasiaticus* could be due to seasonal differences in nutritional quality of the cultivars. In recent studies, the chemical composition of different cultivars' fruit dates was analyzed. The results showed a significant negative correlation between infestation and carbohydrate content of date fruits (Palevsky *et al.* 2005; Aldosari and Ali 2007; Ben Chaaban and Chermiti 2009).

Several researchers have demonstrated that spider mites produce different populations on various plant cultivars such as *Amphitetranychus viennensis* (Zacher), which was found to be lower when reared on apple cultivars 'Starkrimson Delicious' and 'Golden Delicious' than on 'Amasya' and 'Starking Delicious' (Kasap 2003). Similarly, Kerguelen and Hoddle (2000) found that *O. perseae* mean female longevity increased by 100% from 12 days in May to 24 days in July in the susceptible avocado cultivar 'Hass', while in more resistant cultivars, 'Pinkerton' and 'Lamb Hass', longevity dropped by 30% over the same period on soybean (Razmjou *et al*. 2008). Large differences in r_m values were found for *Tetranychus urticae* reared on eight cultivars of the ornamental crop *Gerbera*, ranging from 0.088/day on 'Bianca' to 0.242/day on 'Sirtaki' (Krips *et al*. 1998).

Tetranychidae are sensitive to the chemical composition of the host plant. Essential nutrient levels, including soluble proteins and carbohydrates, have been associated with the performance of *Tetranychus urticae* (Koch) by several authors (Kielkiewicz and Van de Varie 1990). Studies on *T. urticae* have demonstrated a positive correlation between population growth and leaf sugar concentrations of several host plants (Rodriguez *et al.* 1960; Rodriguez and Campbell 1961).

Carbohydrates play an important role in the development of mites, but with higher levels, they could also be a source of resistance used by plants against mites. Studies conducted by De Angelis *et al*. (1983) show the significance of soluble carbohydrates in injured peppermint leaves which act as an osmotic adjustment in response to mite-induced water stress. Three weeks of *T. urticae* feeding significantly reduced sugar contents in young and mature *Gerbera* leaves (Kielkiewicz 1995).

Kielkiewicz and Van de Vries (1990) demonstrated that mite density was lower on young chrysanthemum leaves than on mature ones. These authors reported that young chrysanthemum leaves appeared to be protected against *T. urticae* by a higher concentration of mono- and polyphenols, although they contained higher levels of nutrients than mature ones. Vásquez *et al*. (2008) observed that the r_m value of *Oligonychus punicae* on grapevine cultivars was highest on 'Sauvignon' (0.292) and 'Tucupita' (0.261), and lowest on 'Sirah' (0.146) and 'Villanueva' (0.135). Secondary metabolite content also varied between the cultivars. Generally, increasing flavonoid content coincided with decreasing reproductive parameters.

Agreement between field observations and laboratory studies was observed. In the Tunisian oasis, comparison of damage among selected date palm cultivars attested that dates of 'Deglet Noor' cultivar are very susceptible and suf-

fer more while those of 'Bessr' and 'Kentichi' cultivars were more resistant.

Detailed studies on *O. afrasiaticus* are very limited. Therefore, further experiments in the laboratory should concentrate on evaluating the effect of date palm date cultivar on the biology of *O. afrasiaticus*.

Identifying differences in varietals' susceptibility is crucial for developing efficient pest control programs. Cultivars that are less susceptible can be left without spraying, or sprayed at a low threshold. Identifying characteristics that enhance resistance to spider damage will enable plant breeders to produce resistant varieties. Finally, increasing cultivar diversity in orchards should be considered as a strategy to reduce damage and associated yield reductions caused by *O. afrasiaticus*.

Further work is required to determine differences in chemical composition of resistant and susceptible cultivars, seasonal variation of these compounds, and their effect on the longevity and fecundity of *O. afrasiaticus*. A better understanding of the biochemical processes that may mediate cultivar resistance to *O. afrasiaticus* will also assist breeding efforts designed to select resistance cultivars.

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