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Research Article

Fruit physicochemical properties of several cultivars of date palm and their influence on the susceptibility to *Oligonychus afrasiaticus* (Acari: Tetranichydae) in the southern of Iran

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Abstract

Sixteen date palm cultivars were studied for their susceptibility to the date palm dust mite, *Oligonychus afrasiaticus*, at Date Palm and Tropical Fruit Research Institute of Bushehr, Iran. Physicochemical attributes of these cultivars were also measured at Kimri stage. The results revealed significant differences among cultivars regarding susceptibility to *O. afrasiaticus*. The cultivars Haleli, Maktoub, Barahi, and Deglet Noor were more resistant to the date palm dust mite than the other cultivars. Significant differences were also observed among cultivars for physicochemical characteristics. Fruit length ranged from 2.18 to 4.15 cm, fruit mid diameter from 1.52 to 2.70 cm, fruit cap diameter from 0.82 to 1.10 cm, pericarp thickness from 1.51 to 6.12 mm, exocarp thickness from 0.24 to 0.54 mm, fruit weight from 4.21 to 17.24 g, kernel weight from 0.23 to 1.47 g, pericarp to kernel weight ratio from 4.45 to 16.67, strand weight from 26.33 to 184.75 g, bunch weight from 1.45 to 10.80 kg, number of strands from 26.33 to 91.33, fruit tissue firmness from 3.08 to 4.76 kg/cm^2. The percentage of infestation to the mite had a significant positive correlation with the Kernel weight, fruit length, and number of strands. Tannin content ranged from 0.97 to 8.13%, TSS from 10.00 to 70.00% Brix, and titratable *acidity* from 0.70 to 1.50%. No significant correlation was observed between chemical characteristics of date fruits and infestation to the mite. Such information can be used to screen cultivars of date palm for date fruit processing industries and breeding programs.

Key words: Cultivars, Date palm dust mite, Host plant resistance, *Phoenix dactylifera*

خصوصیات فیزیکوشیمیایی میوه چندین رقم خرما و تاثیر آن بر حساسیت به *Oligonychus afrasiaticus* (Acari: Tetranichydae) در جنوب ایران

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چکیده

شانزده رقم خرما از نظر حساسیت به کنه گرد و غبار خرما *Oligonychus afrasiaticus* در پژوهشکده خرما و میوه‌های گرمسیری بوشهر ارزیابی شدند. صفات فیزیکوشیمیایی این ارقام نیز در مرحله کیمری اندازه‌گیری شد. نتایج نشان داد که

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بین این ارقام از نظر حساسیت به *O. afrasiaticus* تفاوت معنی‌داری وجود دارد. ارقام هلالی، مکتوب، برحی و دقلت نور نسبت به سایر ارقام نسبت به کنه خرما مقاوم‌تر بودند. همچنین از نظر خصوصیات فیزیکوشیمیایی بین ارقام تفاوت معنی‌داری مشاهده شد. طول میوه از ۲/۱۸ تا ٤/۱٥ سانتی‌متر، قطر میانی میوه از ۱/٥۲ تا ۲/۷۰ سانتی‌متر، قطر کلاهک میوه از ۰/۸۲ تا ۱/۱۰ سانتی‌متر، ضخامت پریکارپ از ۱/٥۱ تا ٦/۱۲ میلی‌متر، ضخامت اگزوکارپ از ۰/۲٤ تا ۰/٥٤ میلی‌متر، وزن میوه از ٤/۲۱ تا ۱۷/۲٤ گرم، وزن هسته از ۰/۲۳ تا ۱/٤۷ گرم، نسبت وزن پریکارپ به هسته از ٤/٤٥ تا ۱٦/٦۷، وزن خوشه‌چه از ۲٦/۳۳ تا ۱۸٤/۷٥ گرم، وزن خوشه از ۱/٤٥ تا ۱۰/۸۰ کیلوگرم، تعداد خوشه‌چه از ۲٦/۳۳ تا ۹۱/۳۳ و سفتی بافت میوه از ۳/۰۸ تا ٤/۷٦ کیلوگرم بر سانتی‌متر مربع متغیر بود. درصد آلودگی به کنه با وزن هسته، طول میوه و تعداد خوشه‌چه‌ها همبستگی مثبت و معنی‌دار داشت. محتوای تانن از ۰/۹۷ تا ۸/۱۳ درصد، TSS از ۱۰/۰۰ تا ۷۰/۰۰ درصد بریکس و اسیدیته قابل تیتراسیون از ۰/۷۰ تا ۱/٥۰ درصد متغیر بود. همبستگی معنی‌داری بین ویژگی‌های شیمیایی میوه خرما و آلودگی به کنه مشاهده نشد. از چنین اطلاعاتی می توان برای غربالگری ارقام نخل خرما برای صنایع فرآوری میوه خرما و برنامه‌های اصلاحی استفاده کرد.

واژه‌های کلیدی: ارقام، کنه گرد و غبار خرما، مقاومت گیاه میزبان، *Phoenix dactylifera*

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Introduction

The oldest and most popular fruit tree, date palm, *Phoenix dactylifera* L. (Arecaceae), is found in the hot dried areas of the world. It is particularly found in the Gulf countries of the Middle East (Saleh *et al*., 2011). After pistachio, date palm is the second most prime agricultural crop of Iran (Hajian & Hamidi-Esfahani, 2015). Annually, about 1,000,000 metric tons' date fruits are produced in Iran and is second-largest date-producing country after Egypt in the world (FAO STAT, 2016). Over the world, Iran have more than 400 cultivars of date palm fruits among 3,000 named cultivars (Hajian & Hamidi-Esfahani, 2015). The classification of these cultivars is based on their moisture content as dry, semi-dry and soft (Pezhman, 2002).

In most of the Middle East and the North Africa, an important pest of date palms is the date palm dust mite, *Oligonychus afrasiaticus* (MCG.) (Acari: Tetranychidae) (Negm *et al*., 2015). The mite activity in Iran usually begins around mid-May (The mite feed upon immature green dates and its peak infestation occurs in early July. The fruits attacked by mite are turned into reddish-brown and have a scarred appearance (Chaaban *et al*., 2011). The hard fruit skin after infestation, cracks and shrivels results in reduced grade of fruits and making such fruits unmarketable (Chaaban *et al*., 2011). The mite spins silken webs around the strands and date fruits; adhering dust and sand grains to these webs causes the date bunches to look dusty (Al-Doghairi, 2004). The infestation rate of this pest could reach 100% of the infested bunches.

In Iran, the use of chemical pesticides and wide range applications of acaricides is main strategy to control and prevent the infestation of mite to dates. Because of the negative impacts of chemical control programs such as *O. afrasiaticus* resistance to acaricides (Ho,

2000, Al-Doghairi, 2004, Blumberg, 2008), attention should be given to other control methods against this pest.

The use of resistant cultivars is the main strategy and sustainable management of *O. afrasiaticus* to reduce the pesticide resistance development (Latifian, 2017). The identification of differences in date palm cultivar susceptibility to *O. afrasiaticus* is crucial as a beneficial part of an integrated pest management (IPM) system. The cultivars which are less susceptible can be sprayed or left unsprayed at a minimum threshold (Chaaban *et al*., 2011). Additionally, beneficial natural enemies' effects can be enhanced partially by use of resistant cultivars (Kaplan & Thaler, 2010). The resistance of date palm cultivars towards *O. afrasiaticus* has been investigated by some researchers (Latifian *et al*., 2007, Ben Chaaban & Chermiti, 2009, Ben Chaaban *et al*., 2012). This study presents data on vulnerability of 16 date palm cultivars to *O. afrasiaticus* and some of their physicochemical characteristics.

Materials and methods

Study area and evaluation of susceptibility of date palm cultivars to *O. afrasiaticus*

The experiment was performed in one date palm orchard at Date Palm and Tropical Fruit Research Institute of Bushehr province, Borazjan (Southern Iran), in 2018. Sixteen cultivars of date palm were selected for this study, namely Piarom, Haleli, Toori, Medjool, Zahedi, Maktoub, Hallawi, Barahi, Deglet Noor, Mazafati, Shahabi, Abu Narnjah, Khazab, Shahani, Kabkab, Estaamaran. The infestation of dust mite in the study area usually starts from the middle of June and reaches its peak during July. Three date palms naturally infested by the dust mite were randomly selected per cultivar, marked, and their different characteristics were measured. The selected trees were 15 years old, nearly uniform in size, growth, and vigor. They were kept under normal schedule of cultural practices without treatment of any acaricides or insecticides during period of study. The evaluation of the resistance was performed when the date palm dust mite abundance was at its peak in July and the date fruits of 16 cultivars were in the Kimri stage. The percentage of infestation of date palm cultivars to the pest was evaluated based on the rate of fruits infested by *O. afrasiaticus*. In this case, four fruit strands per bunch of each sampling tree were randomly collected, and the number of healthy and infested fruits was counted. Infested fruits are characterized by the cuticle scarring, presence of webbing, and dusty appearance.

Physical properties

To determine the physical characteristics of fruits, 15 fruits *in the* Kimri stage were randomly collected per sampling tree, each from a different strand. Vernier caliper (Mitutoyo, Japan) was used to measure fruit length (cm), mid diameter (cm), and cap diameter (cm), pericarp thickness (mm), and exocarp thickness (mm) and its accuracy was 0.02 mm. Fruit weight and kernel weight were also measured on a digital scale with an accuracy of 0.001 g and recorded in gram (g). The kernel was taken out, and pericarp was weighed for pericarp to kernel weight

ratio. The same strands selected for evaluation of the pest infestation rate were weighed (g) to determine the strand weight. Bunch weight and the number of strands were monitored by random collecting one bunch from each sampling tree. Each bunch was weighed separately using weighing balance and was expressed in kilogram (kg) and the number of its strands was also counted. Fruit tissue firmness (kg/cm^2) was measured on both sides of each fruit using a penetrometer (FT 327, Italy) with a 10 mm diameter probe.

Chemical properties

Methodology of Awad & Al-Qurashi (2012) was used to determine tannins content and expressed as g/100 g fresh weight (fw). Digital refractometer was employed to measure total soluble solids (TSS) as Brix % in fruit juice (Atago, PAL-3, Japan). Titratable acidity (TA) of the juice was determined by titrating it against 0.1 N NaOH in the presence of indicator, phenolphthalein. It was expressed in % malic acid (Awad & Al-Qurashi, 2012).

Statistical analysis

The obtained data were subjected to statistically analysis of variance (ANOVA) and data were analyzed in three replicates by using a completely randomized design with statistical package software (Proc Univariate, SAS Institute 2003, Cary, NC, USA). Tukey's test made comparisons between means at P = 1%. The relationships between traits were evaluated by Pearson's correlations (5 and 1% significance). According to the Ward's method using SAS software, differentiation of the cultivars based on the percentage of infestation by the date palm spider mites was accomplished by cluster analysis.

Results and discussion

The ANOVA results for the evaluated characteristics are shown in Table 1. Significant differences were detected in all measured aspects among the date palm cultivars with a 99% level of confidence (Table 1).

In the current study, a wide variation in the percentage of infestation to *O. afrasiaticus* was observed among the studied cultivars (1.18-95.23%) (Table 2). Two cultivars Piarom and Hallawi showed more than 94% of an infestation. In Saudi Arabia, other researchers have reported susceptibility difference in date palm cultivars to *O. afrasiaticus*. Aldosari & Ali (2007) indicated that date fruit cultivars Rothan and Sokay were highly susceptible to this mite species. In Israel, Deglet Noor cultivar was more targeted than both the Barahi and Medjool and cultivars as reported by Palevsky *et al*. (2005). However, based on our results, both the Deglet Noor and Barahi cultivars showed a similar low infestation by the pest and were within the resistant cultivars. Latifian *et al*. (2007) reported that date palm cultivars had different susceptibility to *O. afrasiaticus* in Khuzestan province, Iran. Similar to our findings, the cultivar Hallawi showed a high level of mite infestation. However, in contrast to the current study results, date fruit cultivars Estaamaran and Barahi were highly susceptible to this mite species (Latifian *et al*., 2007). Effects of cultivar on the life cycle and increase in population of *O. afrasiaticus* and other Tetranychid species had been demonstrated in the

previous studies (Kerguelen & Hoddle, 2000, Razmjou *et al*., 2009, Ben Chaaban *et al*., 2011).

On the other hand, agro-climatic conditions under which the cultivars grow can affect the physicochemical characteristics of cultivars and lead to such differences observed in the susceptibility of the same cultivars to the pest (Altieri & Nicholls, 2003).

Table 2 describes the physical attributes of sixteen date palm cultivars that were analyzed. The average fruit length ranged between 2.18 cm (Barahi) and 4.15 cm (Medjool). The fruit mid diameter values were 1.52 cm (Estaamaran) and 2.70 cm (Medjool), fruit cap diameter 0.82 cm (Abu Narnjah) and 1.10 cm (Kabkab), pericarp thickness 1.51 mm (Estaamaran) and 6.12 mm (Medjool), exocarp thickness 0.24 mm (Medjool) and 0.54 mm (Khazab), fruit weight 4.21 g (Abu Narnjah) and 17.24 g (Medjool), kernel weight 0.23 g (Haleli) and 1.47 g (Medjool), pericarp to kernel weight ratio 4.45 (Estaamaran) and 16.67 (Haleli), strand weight 26.33 g (Haleli) and 184.75 g (Mazafati), bunch weight 1.45 kg (Maktoub) and 10.80 kg (Kabkab), number of strands 26.33 (Shahabi) and 91.33 (Hallawi), fruit tissue firmness 3.08 kg/cm^2 (Shahani) and 4.76 kg/cm^2 (Toori) (Table 2). The results for the date palm cultivar's physical characteristics in this research work illustrated that sixteen cultivars are different to each other in all measured parameters. Elshibli & Korpelainen (2009) described that the variation of date fruit characters depends on the cultivar. Ghnimi *et al*. (2018) also showed considerable variability between 21 date cultivars grown in the UAE for fruit weight and size. The most desirable trait in the date palm is larger fruit size (Johnson *et al*., 2013). In current study, the Medjool cultivar seems the most promising, combined with more fruit size, weight, pericarp thickness, and least exocarp thickness. Determination of physical characteristics of date palm fruits in India showed that the average values of length, mid diameter, and thickness for Medjool fruits were 4.82 cm, 2.90 cm and 2.8 cm, respectively (Mahawar *et al*., 2017). Our outcomes, in general, were near to these studies. However, as Elshibli & Korpelainen (2009) reported that there may be significant variation in same cultivars in their fruit size in different seasons and locations as a result environment and cultural practices. For example, the fruit size reported for Medjool, Haleli, and Barahi at Kimri stage in Saudi Arabia were 9, 6, and 3 g, respectively (Awad *et al*., 2011), which were close to our findings, except for Medjool. The other promising cultivar in our study was Kabkab because of its bigger fruits. Potentially agronomical enhanced cultivars can be developed from both of these useful cultivars.

Table 1. Analysis of variance for different characteristics in sixteen date palm cultivars infested with *Oligonychus afrasiaticus*.

		Mean Squares															
Source of variation	df	Fruit length	Fruit mid diameter	Fruit cap diameter	Pericarp thickness	Exocarp thickness	Fruit weigh t	Kernel weight	Pericarp to kernel weight ratio	Strand weight	Bunch weight	Number of strands	Fruit tissue firmness	Tannin	TSS[1]	TA[2]	Percentage of infestation
Cultivar	15	1.051**	0.280**	0.020**	4.231**	0.013**	37.849**	0.372**	749.46**	6664.337**	31.950**	851.665**	0.561**	0.001**	0.087**	0.213**	25.131**
Error	32	0.302	0.050	0.003	0.362	0.003	0.867	0.032	2.149	174.615	0.257	22.229	0.066	0.0002	0.006	0.017	0.836
CV[3] (%)	--	17.14	11.53	6.51	16.54	17.60	13.29	20.68	15.42	17.61	10.63	14.95	6.51	17.06	18.51	12.93	17.71

**: significant at 1%
[1]Total Soluble Solids
[2]Titratable acidity
[3]Coefficient of variation

Table 2. Mean comparison of physical characteristics and percentage of infestation in sixteen date palm cultivars infested with *Oligonychus afrasiaticus*.

Cultivar	Physical characteristics												
	Fruit length (cm)	Fruit mid diameter (cm)	Fruit cap diameter (cm)	Pericarp thickness (mm)	Exocarp thickness (mm)	Fruit weight (g)	Kernel weight (g)	Pericarp to kernel weight ratio	Strand weight (g)	Bunch weight (kg)	Number of strands	Fruit tissue firmness (kg/cm^2)	Percentage of infestation
Kabkab	3.96^{ab}	2.39^{ab}	1.10^{a}	4.10^{abc}	0.26^{b}	13.72^{b}	0.991^{a-d}	12.40^{ab}	168.58^{ab}	10.80^{a}	54.33^{b}	3.77^{bcd}	7.57^{efg}
Estaamaran	2.44^{ab}	1.52^{c}	0.83^{c}	1.51^{f}	0.31^{b}	3.37^{e}	0.75^{c-f}	4.45^{c}	52.92^{fg}	1.80^{c}	31.00^{cde}	3.90^{a-d}	2.63^{efg}
Hallawi	3.96^{ab}	1.79^{bc}	0.93^{abc}	2.93^{c-f}	0.27^{b}	5.78^{cde}	0.87^{a-f}	5.90^{c}	106.92^{cde}	5.54^{b}	91.33^{a}	2.28^{cd}	94.12^{a}
Shahani	3.74^{ab}	2.13^{abc}	0.90^{abc}	2.82^{def}	0.32^{b}	5.58^{cde}	1.24^{abc}	6.17^{c}	127.33^{bcd}	9.58^{a}	54.00^{b}	3.08^{d}	7.81^{d-g}
Mazafati	3.63^{ab}	2.23^{abc}	1.08^{ab}	4.90^{a-d}	0.35^{ab}	8.05^{c}	0.95^{a-e}	13.85^{ab}	184.75^{a}	5.77^{b}	32.00^{cde}	3.53^{bcd}	27.50^{c-f}
Zahedi	3.18^{ab}	1.97^{abc}	1.08^{ab}	2.47^{ef}	0.35^{ab}	6.15^{cde}	1.44^{ab}	5.20^{c}	139.83^{abc}	10.41^{a}	53.67^{b}	3.90^{a-d}	49.46^{a-d}
Shahabi	3.43^{ab}	1.89^{bc}	0.95^{abc}	3.43^{b-f}	0.30^{b}	6.71^{cde}	1.05^{a-d}	6.42^{c}	125.92^{bcd}	1.62^{c}	26.33^{e}	4.14^{abc}	34.50^{b-e}
Barahi	2.18^{b}	1.97^{abc}	0.89^{abc}	3.70^{b-e}	0.33^{b}	4.73^{de}	0.34^{ef}	13.65^{ab}	62.85^{efg}	1.53^{c}	47.33^{bc}	3.90^{a-d}	1.18^{g}
Abu Narnjah	2.76^{ab}	1.56^{c}	0.82^{c}	3.35^{b-f}	0.37^{ab}	4.21^{e}	0.51^{def}	12.55^{ab}	49.42^{fg}	2.00^{c}	46.00^{bcd}	3.94^{a-d}	8.35^{d-g}
Haleli	2.46^{ab}	1.75^{bc}	0.86^{bc}	5.00^{ab}	0.32^{b}	5.07^{cde}	0.23^{f}	16.67^{a}	26.33^{g}	1.52^{c}	30.00^{de}	4.40^{ab}	1.62^{g}
Khazab	2.86^{ab}	1.83^{bc}	1.01^{abc}	3.86^{b-e}	0.54^{a}	5.88^{cde}	0.69^{cdef}	8.70^{bc}	68.08^{efg}	3.10^{c}	32.32^{cde}	4.32^{ab}	8.26^{efg}
Toori	2.86^{ab}	1.73^{bc}	1.00^{abc}	3.04^{b-f}	0.36^{ab}	5.30^{cde}	0.87^{a-f}	6.03^{c}	81.33^{def}	5.90^{b}	32.00^{cde}	4.76^{a}	83.16^{ab}
Deglet Noor	3.23^{ab}	1.81^{bc}	0.89^{abc}	2.67^{ef}	0.31^{b}	5.97^{cde}	0.64^{c-f}	9.22^{bc}	42.14^{abc}	5.07^{b}	34.00^{cde}	4.35^{ab}	1.94^{fg}
Medjool	4.15^{a}	2.70^{a}	1.02^{abc}	6.12^{a}	0.24^{b}	17.24^{a}	1.47^{a}	11.76^{ab}	152.50^{abc}	6.47^{b}	54.33^{b}	3.96^{a-d}	64.48^{abc}
Maktoub	2.96^{ab}	2.12^{abc}	1.00^{abc}	4.31^{a-e}	0.35^{ab}	7.64^{cd}	0.82^{b-f}	13.60^{ab}	88.17^{def}	1.45^{c}	31.00^{cde}	4.25^{ab}	1.61^{g}
Piarom	2.45^{ab}	1.80^{bc}	0.92^{abc}	2.10^{b-f}	0.25^{b}	6.32^{cde}	1.13^{a-d}	5.47^{c}	71.17^{efg}	2.94^{c}	58.33^{b}	3.65^{bcd}	95.23^{a}

Means followed by the same superscript letters in columns do not differ by the Tukey test ($\alpha = 0.01$).

The results for tannin, total soluble solids (TSS), and titratable acidity (TA) of the date palm from the different cultivars are given in Table. Table 3 shows that a significant variation in terms of tannin content found among the date palm cultivars, and it ranged between 0.97% (Barahi) and 8.13% (Deglet Noor). In Saudi Arabia, Barahi showed the lowest (0.7%), and Medjool showed the highest (1.7%) concentrations of soluble tannins among the five tested cultivars at the Kimri stage (Awad *et al*., 2011). The variation in comparison with the current research data may be due to other parameters such as region, climate, fertilizer application and type of cultural practices. Based on our results, the TSS values ranged between 10.00% Brix (Hallawi) and 70.00% Brix (Toori), and TA ranged between 0.70% (Shahabi, Maktoub and Barahi) and 1.50% (Estaamaran) (Table 3). Mortazavi *et al*. (2015) reported that TSS for Zahedi & Barahi cultivars at Tamar stage were 75.3 and 70%, and TA were 1.6 and 1.15%, respectively. These values were greater than those obtained in the current study for these cultivars, which could be due to differences in the growth stage of date fruits.

Table 3. Mean comparison of biochemical characteristics of fruits in sixteen date palm cultivars infested with *Oligonychus afrasiaticus*.

Cultivar	Tannin (%)	TSS[1] (% Brix)	TA[2] (%)
Kabkab	1.27^{d}	26.67^{def}	0.80^{def}
Estaamaran	1.63^{bcd}	26.67^{def}	1.50^{a}
Hallawi	2.30^{bcd}	10.00^{f}	1.20^{a-d}
Shahani	1.47^{cd}	16.67^{ef}	0.80^{c-f}
Mazafati	1.20^{d}	23.33^{def}	1.00^{b-f}
Zahedi	1.10^{d}	26.67^{def}	1.20^{a-e}
Shahabi	6.13^{ab}	63.33^{ab}	0.70^{ef}
Barahi	0.97^{d}	33.33^{c-f}	0.70^{f}
Abu Narnjah	5.50^{a-d}	50.00^{a-d}	1.20^{a-d}
Haleli	2.57^{bcd}	30.00^{def}	0.90^{b-f}
Khazab	6.07^{abc}	40.00^{b-e}	0.80^{def}
Toori	2.50^{bcd}	70.00^{a}	1.20^{a-d}
Deglet Noor	8.13^{a}	60.00^{abc}	1.30^{ab}
Medjool	5.23^{a-d}	40.00^{b-e}	0.80^{def}
Maktoub	1.10^{d}	43.33^{a-e}	0.70^{f}
Piarom	3.67^{a-d}	46.67^{a-d}	1.00^{b-f}

Means followed by the same superscript letters in columns do not differ by the Tukey test (α = 0.01).
[1]Total Soluble Solids
[2]Titratable acidity

Pearson's correlations revealed that fruit length had a significant positive correlation with the fruit mid diameter (r = 0.55), fruit cap diameter (r = 0.43), fruit weight (r = 0.56), kernel weight (r = 0.56), strand weight (r = 0.61), bunch weight (r = 0.42), number of strands (r = 0.40), and percentage of infestation (r = 0.32) (Table 4). In a recent study conducted on 21 date cultivars grown in UAE, a significant positive correlation between fruit length and mid-diameter with fruit weight was observed. Correlation between fruit length and kernel weight was also positive and significant (Ghnimi *et al*., 2018). Pearson's correlation evaluates between fruit mid diameter and fruit cap diameter with pericarp thickness, fruit weight, kernel weight, strand weight, and bunch weight were also positive and significant (Table 4). Pericarp thickness had a positive and significant correlation with fruit weight (r = 0.67) and pericarp to kernel weight ratio (r = 0.68). A positive and significant correlation was observed between

exocarp thickness with fruit tissue firmness (r = 0.32). The minimum r_m of *O. afrasiaticus* on cultivars of date fruit may be attributed to date fruit exocarp thickness (Ben Chaaban *et al*., 2011). However, in this study, no significant correlation was found between exocarp thickness and mite damage to the fruits. Fruit weight had significant positive correlation estimates with kernel weight (r = 0.49), and both of these characteristics had positive and significant correlation with strand weight and bunch weight. Ghnimi *et al*. (2018) also reported a positive and significant correlation between date fruit weight and kernel weight (r = 0.271). Kernel weight had a significant negative correlation with pericarp to kernel weight ratio (r = -0.54), and a positive and significant correlation with the percentage of infestation (r = 0.44). Pericarp to kernel weight ratio had a negative and significant correlation with TSS (r = -0.54), TA (r = -0.39), and percentage of infestation (r = -0.45). Positive and significant correlations were detected between strand weight with bunch weight (r = 0.67) and between bunch weight with the number of strands (r = 0.42). Both bunch weight and the number of strands had negative and significant correlation estimates with fruit tissue firmness. Fruit tissue firmness had a significant positive correlation with TSS (r = 0.55). TA had significant negative estimates of correlation with fruit mid diameter (r = -0.46), fruit cap diameter (r = -0.32), pericarp thickness (r = -0.56), fruit weight (r = -0.40), and pericarp to kernel weight ratio (r = -0.39) (Table 4). The percentage of infestation had a significant positive correlation with the number of strands (r = 0.39). No significant correlation was observed between chemical characteristics of date fruits and infestation to the mite in the current study. In contrast to our results, Aldosari & Ali (2007) reported that susceptibility to *O. afrasiaticus* had a significant positive correlation with the protein and a negative correlation with the carbohydrate content of date fruits. In the studies conducted by Palevsky *et al*. (2005) and Ben Chaaban & Chermiti (2009), resistance to *O. afrasiaticus* was positively and negatively correlated with TSS and water content respectively.

Table 4. Estimates of Pearson's correlations among the evaluated characteristics in date palm cultivars submitted to infestation of *Oligonychus afrasiaticus*.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) Fruit length	1	0.55**	0.43**	0.23^{ns}	-0.24^{ns}	0.56**	0.56**	-0.11^{ns}	0.61**	0.42**	0.40**	-0.11^{ns}	0.12^{ns}	-0.11^{ns}	-0.12^{ns}	0.32*
(2) Fruit mid diameter		1	0.70**	0.56**	-0.15^{ns}	0.78**	0.47**	0.28*	0.60**	0.43**	0.14^{ns}	-0.15^{ns}	-0.21^{ns}	-0.15^{ns}	-0.46**	0.02^{ns}
(3) Fruit cap diameter			1	0.42**	0.05^{ns}	0.58**	0.41**	0.13^{ns}	0.57**	0.37**	-0.04^{ns}	-0.08^{ns}	-0.09^{ns}	-0.08^{ns}	-0.32*	0.14^{ns}
(4) Pericarp thickness				1	-0.02^{ns}	0.67**	-0.01^{ns}	0.68**	0.24^{ns}	0.03^{ns}	-0.06^{ns}	-0.14^{ns}	0.12^{ns}	-0.14^{ns}	-0.56**	-0.11^{ns}
(5) Exocarp thickness					1	-0.30*	-0.31*	0.10^{ns}	-0.22^{ns}	0.13^{ns}	-0.34*	0.32*	0.07^{ns}	0.11^{ns}	-0.06^{ns}	-0.10^{ns}
(6) Fruit weight						1	0.49**	0.26^{ns}	0.58**	0.42**	0.18^{ns}	-0.06^{ns}	0.16^{ns}	-0.09^{ns}	-0.40**	0.16^{ns}
(7) Kernel weight							1	-0.54**	0.60**	0.57**	0.30*	-0.33*	-0.02^{ns}	-0.16^{ns}	-0.05^{ns}	0.44**
(8) Pericarp to kernel weight ratio								1	-0.04^{ns}	-0.22^{ns}	-0.25^{ns}	0.21^{ns}	0.01^{ns}	0.54**-	-0.39**	-0.45**
(9) Strand weight									1	0.67**	0.17^{ns}	-0.14^{ns}	0.02^{ns}	0.02^{ns}	-0.13^{ns}	0.15^{ns}
(10) Bunch weight										1	0.42**	-0.34*	0.30*-	-0.22^{ns}	0.02^{ns}	0.20^{ns}
(11) Number of strands											1	0.57**-	-0.16^{ns}	0.42**-	0.08^{ns}	0.39**
(12) Fruit tissue firmness												1	0.24^{ns}	0.55**	0.08^{ns}	-0.16^{ns}
(13) Tannin													1	0.22^{ns}	-0.01^{ns}	-0.00^{ns}
(14) TSS[1]														1	0.22^{ns}	0.04^{ns}
(15) TA[2]															1	0.17^{ns}
(16) Percentage of infestation																1

^{ns}, *and **: Not significant, significant at 5% and 1%, respectively.

[1]Total Soluble Solids

[2]Titratable acidity

Sixteen evaluated date palm cultivars were separated into three distinctive categories by results of cluster of analysis, including Hallawi, Piarom, Toori, Zahedi, & Medjool as susceptible, Mazafati, Shahabi, Abu Narnjah, Khazab, Shahani, Kabkab, & Estaamaran as partially resistant, and Haleli, Maktoub, Barahi, & Deglet Noor as resistant cultivars (Figure 1).

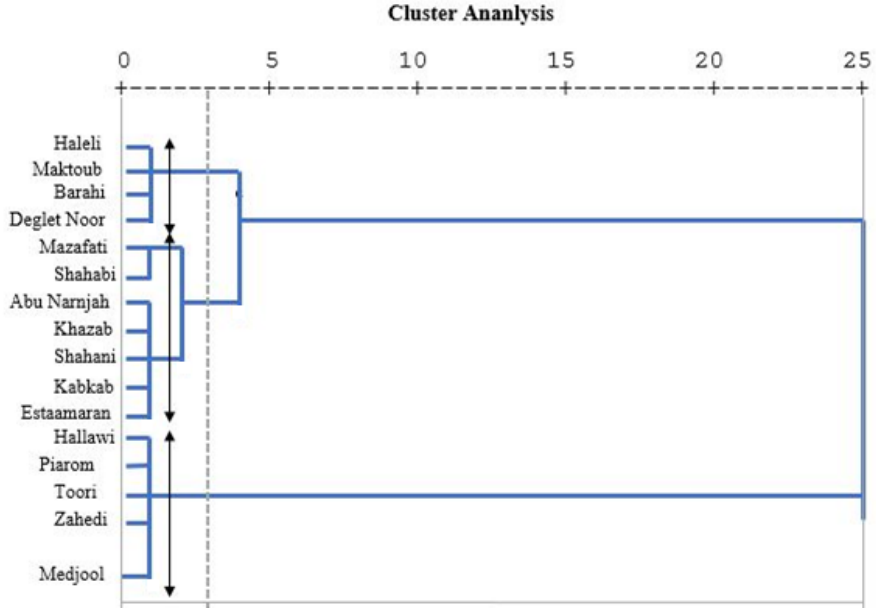

Fig. 1. Dendrogram of 16 date palms cultivars for percentage of infestation with *Oligonychus afrasiaticus* using hierarchical cluster analysis (Ward's method).

Conclusion

There was observed statistically significant differences between date palm cultivars explored in parameters measured. This indicates that cultivar is the major parameter to determine the physicochemical parameters and susceptibility to *O. afrasiaticus* in date palms. Among the sixteen cultivars studied, Medjool & Kabkab cultivars had superior physical fruit characteristics, but Medjool showed high susceptibility to *O. afrasiaticus*. Among the four cultivars Haleli, Maktoub, Barahi, & Deglet Noor, with a low level of mite infestation, Maktoub & Deglet Noor showed a high content TSS. Deglet Noor also had a high level of soluble tannins and TA. Such information can be useful for date fruit processing industries and selecting desirable date palm genotypes for breeding programs. There is need for additional analyses with molecular markers to indicate the possible genetic variation in date palm cultivars.

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