



EFFECT OF KAOLIN FOLIAR ON FRUIT SUNBURN, YIELD AND FRUIT QUALITY OF PERSIMMON TREES

H. M.A. Abo Ogiela

Deciduous Fruit Trees Research Department.

Horticulture Research Institute, Agriculture Research Center, Giza, Egypt

Received: Mar. 8, 2020

Accepted: Jun. 22, 2020

ABSTRACT: A field experiment was conducted during 2016 and 2017 seasons at a private orchard situated in Abu El-Matamir district, El-Behaira governorate, Egypt, to study the effect of foliar spray of 0, 2, 3 and 4% kaolin, twice or three times in June, July and August on vegetative growth, nutritional status, sunburn percentage, yield and fruit quality of "Costata" persimmon trees. The obtained results showed that, kaolin foliar application at 4% twice or three times (T_6 and T_7) considered the best treatments for enhance improvement nutritional status of trees. Moreover, kaolin foliar applications were effective to control fruit sunburn % as well as reducing severity percentage of sunburned fruits as compared to untreated trees. Also, Kaolin foliar application at three times was decreased leaf and fruit surface temperature especially under 3 and 4% concentrations. In addition, kaolin treatments increased yield and improved fruit quality in terms of fruit weight, size, height, and diameter as well as fruit firmness. Kaolin foliar spray was raising fruit values of SSC%, and SSC/acid ratio compared to the control, whereas there is no significant variation among kaolin concentrations on this variables. Therefore, it could be recommended that, spraying kaolin at 4% three times in summer months, improving increasing gave the best result for improving trees nutritional status, and also it had a positive effect on preventing fruit sunburn damage and increasment yield and fruit quality of "Costata" persimmon trees.

Key words: Diospyros kaki, Kaolin, Sunburn, Yield, Fruit quality, solar injury

INTRODUCTION

Japanese persimmon (*Diospyros kaki*, L.) belongs to the family Ebenaceae; it has been cultivated in Egypt since 1911, and successfully grown under the Egyptian environmental conditions due to its low chilling requirements Guirguis *et al.*, (2010). So, persimmon increased rapidly and cultivation spreads in many areas in Egypt. However, intense exposure of the persimmon fruit to sunlight can cause sunburn damage looks like large black spots on the fruit skin, which render the fruit unmarketable; and also the incidence of sunburn damage cause high losses in yield and reducing income for growers Schrader *et al.*, (2008) and Lal, Sahu (2017). Therefore, the high susceptibility of fruit to sunburn would suggest the

need for external intervention to suppress sunburn in fruit. In this respect, foliar spraying with kaolin is an effective method to reduce sunburn in various fruit crops Aly *et al.*, (2010); Colavita *et al.*, (2011) and Vatandoost *et al.*, (2014). Kaolin particles make films on the leaves and fruits, which reflect sunlight this may be due to lowering the temperature of leaf surface and fruits thereby reducing sunburn and improving fruit quality. Ennab *et al.*, (2017) and Baiea *et al.*, (2018). Kaolin (a clay) is a natural material whose main constituent is kaolinite ($Al_2Si_2O_5OH_4$). Kaolin clay treatments have been successfully applied in different fruit species to minimize fruit sunburn and improve yield and fruit quality Kerns and Wright, (2000); Colavita *et al.*, (2011) and Alvarez *et al.*, (2015).

Kaolin-based particle films can reduce insect, heat, and ultraviolet stress in horticultural crops because of their ability to modify the microenvironment of the plant canopy as a result of the reflective nature of the particles, Glenn, (2012). Kaolin was significantly effective for reducing apple fruits temperature, the products effectiveness is often expressed in terms of damaged fruit, Alvarez *et al.*, (2015). In this line, Glenn, (2009) mentioned that, kaolin foliar spray on apple tree to reflect sunlight, led to lower the temperature of fruit surface, reducing sun injuries as well as improving yield and fruit quality. Also, Ennab *et al.* (2017) concluded that, kaolin foliar applications at 3 and 4% decreased leaf and fruit surface temperature and was more effective to control fruit sunburn% of "Balady" mandarin trees.

Therefore, the aim of this study is to investigate the effect of kaolin application in different concentrations and times on reducing sunburn and improving yield and fruit quality of persimmon cv Costata .

MATERIALS AND METHODS

The present study was carried out during 2016 and 2017 seasons on 12 years old Costata persimmon trees (*Diospyros kaki*, L.) budded on Tarabuls (*Diospyrous lotus*) rootstock, planted at 4x4 meter apart in a private orchard situated at Abu El-Matamir destrict, El-Behaira governorate, Egypt (30 66 N latitvde and 30 06 E longrude). The trees grown in calcareous soil under drip irrigation system; and it received the same cultural practices usually done in this area. The metrological data of the studied period were illustrated in Fig. (1). Forty two trees were selected as uniform as possible in size and load, and arranged in a randomized complete block design, each treatment replicated three times with two trees for each replicate.

Seven treatments were chosen to study the effect of kaolin foliar applications in different concentrations and times on reducing sunburn and improving fruit quality of "Costata" persimmon trees as follows:

- T₁ Control (spray with tap water only)
- T₂ Spraying Kaolin at 2% twice (15 June and 15 July)
- T₃ Spraying Kaolin at 2% three times (15 June, 15 July and 15 August)
- T₄ Spraying Kaolin at 3% twice (15 June and 15 July)
- T₅ Spraying Kaolin at 3% three times (15 June, 15 July and 15 August)
- T₆ Spraying Kaolin at 4% twice (15 June and 15 July)
- T₇ Spraying Kaolin at 4% three times (15 June, 15 July and 15 August)

The following data was recorded:

1. Nutritional status:

Twenty mature mid-shoot leaves in leat August were sampled to determined chlorophyll a, b and its total by using N, N dimethyl formamide according to Moran and Porath (1980). The remaining leaf samples were dried at 70°C to a constant weight, then ground and digested according to Jackson (1967) by using the mixture of concentrated Sulfuric acid (H₂SO₄) + per chloric (HClO₄) (5: 1) to determine the elements N, P, K, Ca, Mg, Fe, Mn and Zn. Total nitrogen (%) was determined by using the micro-kjeldahl method as described by Pregl (1945), Phosphorus % was determined colorematically as described by Murphy and Riley (1962), Potassium % was estimated by using flame photometer as described by Brown and Lillceland (1974), Ca, Mg, Fe, Mn and Zn were assayed with Atomic Absorption spectrophotometer (Unican SP 1900) according to Chapman and Pratt (1961).

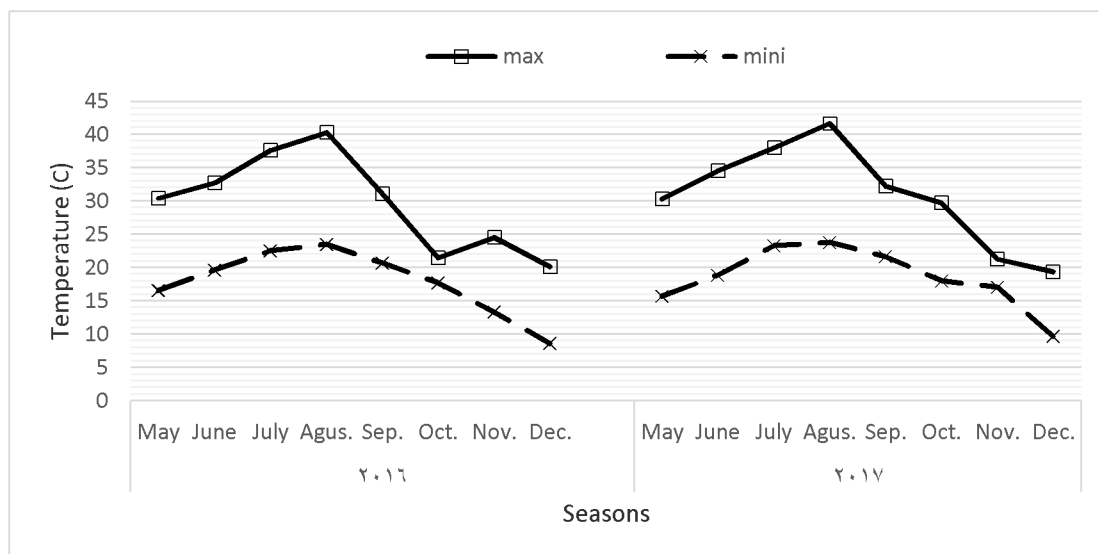


Fig. (1): Mean of maximum and minimum temperature data for Abou El-Matamir area during 2016 and 2017 seasons.

2. Leaf and fruit surface temperature:

Leaf and fruit surface temperature were measured on thirty fruit and leaves/tree on a hot months June, July and August on the sunny side of treated and control trees using an infra-red thermometer.

3. Fruit sunburn percentage:

Sunburned fruits were counted and the percentage of sunburn was calculated by using the following equation:

$$\text{Sunburn \%} = \frac{\text{No. of sunburned fruits}}{\text{Total No. of fruits}} \times 100$$

4. Severity (%) of sunburned fruits:

At harvest time, all sunburned fruit per tree were divided according to sun injuries to three categories according to black spots area on the fruit skin as (less than 10%), medium (10 to 20%) and high (more than 20%).

5. Yield:

At harvest time (September 21th and 15th) in 2016 and 2017 season respectively yield of each replicate was determined as number and weight (kg) of fruits/tree, and total yield as ton/feddan was estimated .

6. Fruit quality:

Ten fruits were sampled random from each replicate to determine fruit quality as follow: fruit weight (g), fruit size (cm³), fruit height and diameter (cm), and fruit firmness (lb/inch²) were measured at two opposite sides on the equator of each fruit using pressure tester at 5/16 plunger. Total soluble solids (TSS%) was determined by hand refractometer, total acidity as malic acid and total tannin content in fruit juice were determined according to A.O.A.C., (1990).

Statistical analysis

The data were statistically analyzed as analysis of variance according to Snedecor and Cochran (1990). Duncan's

multiple range test Duncan, (1955) at 5% level was used to compare the mean values.

RESULTS AND DISCUSSION

1. Nutritional status:

Leaf chlorophyll content ($\mu\text{g}/\text{cm}^2$):

Regarding the effect of kaolin foliar application on leaf chlorophyll content of "Costata" persimmon trees, results presented in Table (1) showed that, chlorophyll a, b and its total content were significantly improved with kaolin spraying in both seasons. T₆ (Kaolin at 4% twice) and T₇ (Kaolin at 4% three times) recorded the highest values of chlorophyll a, b and its total contents. On the other hand, T₁ (control) recorded the least values in this respect in both

seasons. Whereas, T₂, T₃, T₄ and T₅ gave intermediate values in this respect. These results are similar to those of previous studies Lombardini *et al.*, (2005) and Sotelo-Cuitiva *et al.*, (2011).

Leaf mineral content:

Data presented in Tables (2 and 3) revealed that all kaolin treatments significantly increased the leaf macronutrients (N, P, K, Ca, Mg, Fe, Mn and Zn) as compared with control in both seasons. Furthermore, spraying kaolin at 4% twice or three times (T₆ and T₇) recorded the highest values of leaf mineral content comparing with control in both seasons. These results are in parallel with those obtained by Stanley, (1998), Schupp *et al.*, (2002) and Aly *et al.*, (2010).

Table (1): Effect of foliar spraying with kaolin on leaf chlorophyll content of Costata persimmon trees during 2016 and 2017 seasons.

Treatments	Leaf chlorophyll content ($\mu\text{g}/\text{cm}^2$):					
	A		B		Total	
	2016	2017	2016	2017	2016	2017
T ₁ (Cont.)	60.53d	61.35c	27.36c	27.97d	87.89c	89.32c
T ₂	63.81c	65.00b	29.29b	30.05c	93.10c	95.05b
T ₃	63.99c	65.14b	30.46a	30.23bc	94.45b	95.37b
T ₄	64.51bc	64.96b	31.01a	31.05abc	95.52b	96.01b
T ₅	65.46ab	65.42b	30.55a	31.17ab	96.01b	96.59b
T ₆	65.37ab	67.10a	31.08a	31.16ab	96.45a	98.26a
T ₇	65.60a	66.66a	31.22a	31.41a	96.82a	98.07a

T₁ Control (spray with tap water only)

T₂ Spraying Kaolin at 2% twice (15 June and 15 July)

T₃ Spraying Kaolin at 2% three times (15 June, 15 July and 15 August)

T₄ Spraying Kaolin at 3% twice (15 June and 15 July)

T₅ Spraying Kaolin at 3% three times (15 June, 15 July and 15 August)

T₆ Spraying Kaolin at 4% twice (15 June and 15 July)

T₇ Spraying Kaolin at 4% three times (15 June, 15 July and 15 August)

Means followed by different letter are significantly different within columns by Duncan's multiple range test, (DMRT).

Effect of kaolin foliar on fruit sunburn, yield and fruit quality of persimmon trees

Table (2): Effect of foliar spraying with kaolin on leaf macronutrients contents (N,P,K and Ca) of "Costata" persimmon trees during 2016 and 2017 seasons.

Treatments	Macronutrients % on D.W t.									
	N		P		K		Ca		Mg	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
T ₁ (Cont.)	1.89b	1.71b	0.159c	0.167c	1.39d	2.13a	1.93e	1.21b	0.626c	0.613b
T ₂	2.18ab	2.05a	0.171b	0.172ab	2.33bc	2.38a	2.15c	2.21a	0.633bc	0.640a
T ₃	2.20ab	2.18a	0.171b	0.173ab	2.33bc	2.22a	2.01d	2.33a	0.646b	0.643a
T ₄	2.12b	2.07a	0.171b	0.174a	2.13c	2.28a	2.64a	2.25a	0.670a	0.643a
T ₅	2.12b	2.06a	0.171b	0.174a	2.57ab	2.31a	2.15c	2.44a	0.666a	0.636a
T ₆	2.04b	2.06a	0.174ab	0.172b	2.59a	2.16a	2.45b	2.29a	0.646b	0.633a
T ₇	2.61a	2.09a	0.176a	0.173ab	2.26c	2.38a	2.68a	2.30a	0.666a	0.646a

T₁ Control (spray with tap water only)

T₂ Spraying Kaolin at 2% twice (15 June and 15 July)

T₃ Spraying Kaolin at 2% three times (15 June, 15 July and 15 August)

T₄ Spraying Kaolin at 3% twice (15 June and 15 July)

T₅ Spraying Kaolin at 3% three times (15 June, 15 July and 15 August)

T₆ Spraying Kaolin at 4% twice (15 June and 15 July)

T₇ Spraying Kaolin at 4% three times (15 June, 15 July and 15 August)

Means followed by different letter are significantly different within columns by Duncan's multiple range test (DMRT).

Table (3): Effect of foliar spraying with kaolin on leaf micronutrients (Fe, Mn and Zn) of "Costata" persimmon trees during 2016 and 2017 seasons.

Treatments	Micronutrients (PPm) on D.W t.					
	Fe		Mn		Zn	
	2016	2017	2016	2017	2016	2017
T ₁ (Cont.)	75.00a	74.51c	46.33e	45.57c	17.36c	18.56b
T ₂	76.30a	78.39b	54.36bd	54.36b	18.40b	19.30b
T ₃	71.66a	78.57b	85.20a	62.99a	20.05a	20.68a
T ₄	72.92a	84.53a	59.33b	56.34ab	20.40a	20.54a
T ₅	79.46a	82.26a	58.50c	58.74ab	20.40a	20.91a
T ₆	79.46a	82.03a	58.33c	58.73ab	20.43a	21.20a
T ₇	78.03a	81.87a	58.43c	59.20ab	20.43a	21.26a

T₁ Control (spray with tap water only)

T₂ Spraying Kaolin at 2% twice (15 June and 15 July)

T₃ Spraying Kaolin at 2% three times (15 June, 15 July and 15 August)

T₄ Spraying Kaolin at 3% twice (15 June and 15 July)

T₅ Spraying Kaolin at 3% three times (15 June, 15 July and 15 August)

T₆ Spraying Kaolin at 4% twice (15 June and 15 July)

T₇ Spraying Kaolin at 4% three times (15 June, 15 July and 15 August)

Means followed by different letter are significantly different within columns by Duncan's multiple range test (DMRT).

3. Leaf and fruit surface temperature:

Results presented in Tables (4 and 5) indicated that kaolin treatments significantly decreased leaf and fruit surface temperature compared to the control in both seasons. In this respect, leaf and fruit temperature were decreased by increasing kaolin concentrations from 0 to 4% in both seasons. Moreover, fruit surface temperature recorded higher values than that recorded on leaf in both seasons. This result was true when kaolin sprayed twice at June and July or three times at June, July and August in both seasons. In addition, kaolin at 3 and 4% applied twice or three times (T₄, T₅, T₆ and T₇) recorded the lowest values without significant differences among them in both seasons. On the other hand, the highest temperature recorded of leaf and fruit surface obtained with control trees in both seasons. These results were agreement with those obtained by Gindaba and Wand (2007) on apple,

Colavita *et al.*, (2011) on pear and Chamchaiyaporn *et al.*, (2013) on mango trees.

4. Fruit sunburn (%):

Results presented in Table (6) indicated that, kaolin foliar sprays significantly decreased Fruit sunburn (%) in both seasons. This reduction was proportional to kaolin concentrations. In this respect, control treatment (T₁) gave the highest percentags (29.00 and 29.66%) in both seasons, respectively. In the contrast, the lowest percentags of Fruit sunburn (7 and 7.10) was recorded in kaolin sprays at 4% three times (T₇) in both seasons respectively. These results were similar to those obtained by Yazici and Kaynak (2009) on pomegranate, Colavita *et al.*, (2011) on pear and Abd Alla *et al.*, (2013) on mango. In this respect, Melgarejo *et al.*, (2004) found that spraying pomegranate fruits with kaolin decreased percentage of sunburn from 21.9% to 9.4%.

Table (4): Effect of foliar spraying with kaolin on leaf surface temperature of " Costata " persimmon trees during 2016 and 2017 seasons.

Treatments	June		July		August	
	2016	2017	2016	2017	2016	2017
T ₁ (Cont.)	32.1	32.1	36.1	35.6	37.9	37.1
T ₂	29.1	30.1	31.2	28.1	34.1	34.1
T ₃	28.0	27.5	30.1	29.0	31.2	29.1
T ₄	27.9	26.0	28.0	28.1	28.1	28.5
T ₅	26.1	25.1	27.1	25.5	29.7	26.1
T ₆	27.3	23.8	25.1	26.3	30.1	24.3
T ₇	25.2	22.1	24.3	25.2	28.5	26.4

T₁ Control (spray with tap water only)

T₂ Spraying Kaolin at 2% twice (15 June and 15 July)

T₃ Spraying Kaolin at 2% three times (15 June, 15 July and 15 August)

T₄ Spraying Kaolin at 3% twice (15 June and 15 July)

T₅ Spraying Kaolin at 3% three times (15 June, 15 July and 15 August)

T₆ Spraying Kaolin at 4% twice (15 June and 15 July)

T₇ Spraying Kaolin at 4% three times (15 June, 15 July and 15 August)

Means followed by different letter are significantly different within columns by Duncan's multiple range test(DMRT).

Effect of kaolin foliar on fruit sunburn, yield and fruit quality of persimmon trees

Table (5): Effect of foliar spraying with kaolin on fruit surface temperature of " Costata" persimmon trees during 2016 and 2017 seasons.

Treatments	June		July		August	
	2016	2017	2016	2017	2016	2017
T ₁ (Cont.)	33.1	34.1	38.4	36.3	38.0	40.5
T ₂	31.2	30.2	33.1	33.1	35.6	35.2
T ₃	30.4	30.1	32.2	30.2	33.2	33.9
T ₄	29.1	28.5	30.1	30.1	32.5	32.5
T ₅	28.1	27.1	30.1	28.3	33.4	32.1
T ₆	30.1	26.2	28.2	30.1	32.1	31.4
T ₇	28.1	25.1	29.4	29.2	30.4	30.6

T₁ Control (spray with tap water only)

T₂ Spraying Kaolin at 2% twice (15 June and 15 July)

T₃ Spraying Kaolin at 2% three times (15 June, 15 July and 15 August)

T₄ Spraying Kaolin at 3% twice (15 June and 15 July)

T₅ Spraying Kaolin at 3% three times (15 June, 15 July and 15 August)

T₆ Spraying Kaolin at 4% twice (15 June and 15 July)

T₇ Spraying Kaolin at 4% three times (15 June, 15 July and 15 August)

Means followed by different letter are significantly different within columns by Duncan's multiple range test(DMRT).

Table (6): Effect of foliar spraying with kaolin on the percentage of sunburn and sunburn severity percentages of "Costata" persimmon trees during 2016 and 2017 seasons.

Treatments	Sunburn %		Severity % of sunburned fruit					
			2016			2017		
			Light	Medium	High	Light	Medium	High
T ₁ (Cont.)	29.00a	29.66a	13.33f	45.00a	41.66a	13.66g	45.00a	41.33a
T ₂	19.00b	17.66b	44.00e	37.33b	19.66b	43.66f	37.33b	19.00b
T ₃	16.00c	15.00c	50.66d	34.00c	15.33c	349.66e	34.00c	16.33b
T ₄	14.66d	13.66c	56.33c	31.33d	11.00d	57.00d	31,33d	12.00c
T ₅	9.66e	9.33d	59.00b	28.66e	11.33d	59.66c	28.66e	11.66c
T ₆	8.00f	68.00de	61.00b	28.00e	10.00d	67.00b	28.00e	10.00c
T ₇	7.00g	7.00e	65.66a	27.33e	6.00e	66.00a	27.33e	6.66d

T₁ Control (spray with tap water only)

T₂ Spraying Kaolin at 2% twice (15 June and 15 July)

T₃ Spraying Kaolin at 2% three times (15 June, 15 July and 15 August)

T₄ Spraying Kaolin at 3% twice (15 June and 15 July)

T₅ Spraying Kaolin at 3% three times (15 June, 15 July and 15 August)

T₆ Spraying Kaolin at 4% twice (15 June and 15 July)

T₇ Spraying Kaolin at 4% three times (15 June, 15 July and 15 August)

Means followed by different letter are significantly different within columns by Duncan's multiple range test (DMRT).

5. Severity (%) of sunburned fruits:

Data presented in Table (7) cleared that, kaolin foliar spray significantly reduced sun injuries on fruits of in both seasons. Spraying kaolin at 3 and 4% three times (T₅ and T₇) reduced sun injuries in light and high categories compared with control and other treatments. The highest sun injuries recorded on sunburned fruits harvested from control treatment (T₁) in medium and high categories in both seasons. These results were in agreement with those obtained by Weerakkody *et al.*, (2010) and Vatandoost *et al.*, (2014). Also, Glenn *et al.*, (2009) and Ennab *et al.*, (2017) revealed that, applications of kaolin at 3 and 6% every 3 weeks reduced solar injury in "Baldy" mandarin fruits.

It is obvious from data in Tables (4, 5 and 6) that, increasing spraying concentrations with replicated three times had a positive effect on decreasing temperature of leaves and fruits

especially at the high concentrations of kaolin (3 and 4 %) compared to the control. This conclusion agree with the findings of Jifon and Syvertsen (2003) found that leaf temperature of grapefruit trees cv Ruby Red treated with 6% kaolin was lower than leaves of untreated trees. Also, Melgarejo *et al.*, (2004) using kaolin on pomegranate trees and found a reduction in leaf and fruit temperature as compared to non-treated ones. Furthermore, treatment of foliar spraying kaolin at 4% three times in summer months showed to be the superior one in reducing sunburn (%) as compared to control and other treatments in both seasons. These results are in harmony with those obtained by Chabbal *et al.*, (2014) and Hegazi *et al.*, (2014) found that, kaolin applied at 4 and 5% reduced sunburn % on "Satsuma" mandarin and pomegranate trees. Such reduction in sunburn percent could be attributed to reduce heat stress and decreasing fruit surface temperature.

Table (7): Effect of foliar spraying with kaolin on yield of "Costata" persimmon trees during 2016 and 2017 seasons.

Treatments	Yield					
	Fruit number/tree		Kg/tree		ton/feddan	
	2016	2017	2016	2017	2016	2017
T ₁ (Cont.)	227.66c	235.00c	29.33d	30.33c	7.68d	7.93c
T ₂	236.33b	241.66b	33.89c	38.11b	8.87c	9.98b
T ₃	240.66ab	243.00b	36.77b	38.24b	9.63b	10.01b
T ₄	239.00b	243.33b	38.20ab	39.56ab	10.00ab	10.36ab
T ₅	239.00b	253.66a	36.85b	39.96ab	9.65b	10.46ab
T ₆	239.33b	250.00a	38.32ab	41.44a	10.03ab	10.46ab
T ₇	244.66a	252.33a	40.18a	42.30a	10.57a	11.06a

T₁ Control (spray with tap water only)

T₂ Spraying Kaolin at 2% twice (15 June and 15 July)

T₃ Spraying Kaolin at 2% three times (15 June, 15 July and 15 August)

T₄ Spraying Kaolin at 3% twice (15 June and 15 July)

T₅ Spraying Kaolin at 3% three times (15 June, 15 July and 15 August)

T₆ Spraying Kaolin at 4% twice (15 June and 15 July)

T₇ Spraying Kaolin at 4% three times (15 June, 15 July and 15 August)

Means followed by different letter are significantly different within columns by Duncan's multiple range test (DMRT).

Effect of kaolin foliar on fruit sunburn, yield and fruit quality of persimmon trees

6. Yield and its components:

Data presented in Table (8) showed that, yield as number of fruits per tree, weight (kg/tree) and ton/feddan of "Costata" persimmon trees was significantly increased by all kaolin treatments comparing with control during 2016 and 2017 seasons. The highest yield was observed with kaolin foliar application of 4% twice or three times (T₆ and T₇) and kaolin at 3% three times (T₅) without significant differences among them in both seasons. However, control and kaolin at 2% twice (T₁ and T₂) gave

the lowest yield as number of fruits per tree, weight kg/tree and ton/feddan compared to other treatments in both seasons. These results were in agreement with those obtained by Kerns and Wright (2000) and Lombardini *et al.*, (2005). In this respect, Abdel Ghani *et al.*, (2013) concluded that, kaolin foliar spray at 5% significantly increased yield as number of fruits per tree or weight (kg) of Aggezi and Picual olive compared to foliar spray with calcium carbonate (5%) and tap water.

Table (8): Effect of foliar spraying with kaolin on some physical fruit properties of "Costata" persimmon trees during 2016 and 2017 seasons.

Treatments	Fruit weight (g)	Fruit size (cm ³)	Fruit height (cm)	Fruit diameter (cm)	Fruit firmness (lb/inch ²)
2016 season					
T ₁ (Cont.)	120.27c	134.3c	5.24d	5.68c	16.94d
T ₂	126.69b	135.5b	6.52c	6.17b	18.05c
T ₃	137.76a	136.1b	6.76bc	7.10a	18.32c
T ₄	134.65a	137.8a	7.23ab	7.20a	19.15b
T ₅	133.64a	135.6b	7.36ab	7.21a	19.84a
T ₆	135.50a	137.4a	7.56a	7.22a	19.91a
T ₇	136.26a	136.9a	7.18abc	7.22a	20.10a
2017 season					
T ₁ (Cont.)	120.09e	133.8c	5.49c	5.45c	16.28c
T ₂	124.18d	135.1b	6.35b	6.53b	18.27b
T ₃	131.17c	137.7a	7.41a	7.65a	18.68b
T ₄	135.98a	136.0b	7.78a	7.25a	20.32a
T ₅	134.54b	135.9b	7.42a	7.56a	21.09a
T ₆	135.64ab	137.0a	7.34a	7.28a	20.76a
T ₇	135.58ab	137.9a	7.34a	7.35a	20.76a

T₁ Control (spray with tap water only)

T₂ Spraying Kaolin at 2% twice (15 June and 15 July)

T₃ Spraying Kaolin at 2% three times (15 June, 15 July and 15 August)

T₄ Spraying Kaolin at 3% twice (15 June and 15 July)

T₅ Spraying Kaolin at 3% three times (15 June, 15 July and 15 August)

T₆ Spraying Kaolin at 4% twice (15 June and 15 July)

T₇ Spraying Kaolin at 4% three times (15 June, 15 July and 15 August)

Means followed by different letter are significantly different within columns by Duncan's multiple range test (DMRT).

7. Fruit quality:

Data in Table (8) showed a significant differences among treatments in both seasons as for physical fruit properties. fruit weight, fruit size, height, diameter and fruit firmness. Spraying kaolin at 4% three times (T₇) gave the highest significant values of fruit weight, size, height, diameter and fruit firmness followed by kaolin at 3% and 2% sprayed three times (T₆ and T₅) compared with the control treatment in both seasons. These results are in accordance with those obtained by Palitha *et al.*, (2010), Abd-Allah *et al.*, (2013) and Hegazi *et al.*, (2014).

Results presented in Table (9) cleared that, SSC% and SSC/acid ratio were significantly lower in the control

treatment (T₁) than those recorded by all kaolin treatments in both seasons. Kaolin treatments gave approximately the same values of SSC and SSC/acid ratio without significant differences among them in most cases. Mean while, acidity and total tannins was slightly decreased by kaolin treatments without any significant differences among all treatments in both seasons. Generally, kaolin treatments enhanced chemical fruit quality in terms of SSC%, acidity and SSC/acid ratio as compared with the control, whereas there is no significant variation among kaolin concentrations on chemical fruit quality. Similar results were obtained by Gindaba and Wand (2007) and Chabbal *et al.*, (2014).

Table (9): Effect of foliar spraying with kaolin on some chemical fruit properties of "Costata" persimmon trees during 2016 and 2017 seasons.

Treatments	SSC (%)		Acidity (%)		SSC/acid (ratio)		Total tannins (mg/100 ml. juice)	
	2016	2017	2016	2017	2016	2017	2016	2017
T ₁ (Cont.)	18.22c	19.06b	0.43a	0.43a	42.37b	43.75b	2.39a	2.59a
T ₂	20.08b	20.43a	0.38a	0.40a	52.48ab	50.45ab	1.72a	1.85a
T ₃	20.49ab	20.39a	0.36a	0.40a	56.91ab	50.65ab	1.72a	1.93a
T ₄	21.23a	20.80a	0.36a	0.38a	59.24a	54.56a	1.79a	1.80a
T ₅	20.90ab	20.76a	0.38a	0.41a	55.95ab	50.84ab	2.02a	1.69a
T ₆	20.98ab	21.23a	0.36a	0.39a	57.94ab	50.45ab	1.83a	1.60a
T ₇	20.80ab	20.76a	0.36a	0.39a	57.61ab	52.38a	1.70a	1.65a

T₁ Control (spray with tap water only)

T₂ Spraying Kaolin at 2% twice (15 June and 15 July)

T₃ Spraying Kaolin at 2% three times (15 June, 15 July and 15 August)

T₄ Spraying Kaolin at 3% twice (15 June and 15 July)

T₅ Spraying Kaolin at 3% three times (15 June, 15 July and 15 August)

T₆ Spraying Kaolin at 4% twice (15 June and 15 July)

T₇ Spraying Kaolin at 4% three times (15 June, 15 July and 15 August)

Means followed by different letter are significantly different within columns by Duncan's multiple range test (DMRT).

CONCLUSION

In light of this study, spraying kaolin at 4% twice or three times (T₆ and T₇) showed to be the best treatments for improving nutritional status and producing maximum yield with high quality of "Costata" persimmon trees, and also had a positive effect on preventing fruit sunburn damage under condition of this study .

REFERENCES

- Abd Allah, A.S.E., E. Abd El-Razek and M.M.S. Saleh (2013). Effect of sun-block materials on preventing sunburn injury of "Keitt" mango fruits. *J. Appl. Sci. Res.*, 9(1): 567 – 571.
- Abdel Ghani, N.A., M.A. Galal, M.E. El-Sayed, S.M. El-Marsafawy and M.A. Omran (2013). Effect of spraying kaolin and calcium carbonate on the productivity of "Aggezi" and "Picual" olive cvs. *J. Plant Production, Mansoura Univ.*, 4(7): 1035 – 1050.
- Alvarez, H.L., C.M. DiBella, G.M. Colavita, P. Oricchio and J. Strachnoy (2015). Comparative effects of kaolin and calcium carbonate on apple fruit surface temperature and leaf net CO assimilation. *Journal of Applied Horticulture*, 17(3): 176 – 180.
- Aly, M., N. Abd El Megeed and R.M. Awad (2010). Reflective particle films affected on sunburn, yield, mineral composition and fruit maturity of 'Anna' apple (*Malus domestica*) trees. *Research Journal of Agriculture and Biological Sciences*, 6(1): 84 – 92.
- Association of official Agriculture chemists (1990). *Official and Tentative Methods of Analysis*, 15th Ed. Washington, D. C., USA.)
- Baiea, M.H.M., S.F. EL Gioushy and H.E.M. El Badawy (2018). Efficacy of kaolin and screen duo spraying on fruit sunburn, yield and fruit quality of Keitt mango fruits. *J. Plant Production, Mansoura Univ.*, 9 (12):1013 – 1020.
- Brown, J.D. and O. Lilleland (1974). Rapid determination of potassium and sodium in plant material and soil extracts by flame photometer. *Proc. Soc. Hort. Sci.*, 48: 341-346.
- Chabbal, M.D., A.B. Piccoli., G.C. Martinez., M.M. Avanza., S.M. Mazza and V.A. Rodriguez (2014). Kaolin applications to control sunburn in 'Okitsu' mandarin. *Cultivos Tropicales*, 35(1): 50 – 56.
- Chamchaiyaporn, T., K. Jutamane, P. Kasemsap, P. Vaithanomsat and C. Henpitak (2013). Effects of kaolin clay coating on mango leaf gas exchange, fruit yield and quality. *Kasetsart J. (Nat. Sci.)* 47:479 – 491.
- Chapman, H.D. and P.F. Pratt (1961). *Methods of Analysis for Soils, Plant and Waters*. Univ. of California, USA., 169-170pp.
- Colavita, G.M., V. Blackhall and S. Valdez (2011). Effect of kaolin particle films on the temperature and solar injury of pear fruits. *Acta Hort.* 909:609 – 616.
- Duncan, D.B. (1955). Multiple ranges and multiple F-tests. *Biometrics*, 11:1 – 42.
- Ennab, H.A., S.A. El Sayed and M.M.S. Abo El Enin (2017). Effect of kaolin applications on fruit sunburn, yield and fruit quality of Balady mandarin (*Citrus reticulata*, Blanco). *Menoufia J. Plant Prod.*, 2:129 – 138.
- Gindaba, J. and S.J. Wand (2007). Do fruit sunburn control measures affect leaf photosynthetic rate and stomatal conductance in Royal Gala apple? *Environmental and Experimental Botany* 59:160 – 165.
- Glenn, D.M. (2009). Particle film mechanisms of action that reduce the effect of environmental stress in Empire Apple. *J. Amer. Soc. Hort. Sci.* 134(3):314 – 321.

- Glenn, D.M. (2012). The mechanisms of plant stress mitigation by kaolin-based particle films and applications in horticultural and agricultural crops. *HortScience* 47(6):710 – 711.
- Guirguis, N.S., E.S. Attala, G.B. Mikhael and M.A. Gabr (2010). Effect of sitofex (CPPU) on fruit set, yield and fruit quality of “Costata” persimmon trees. *J. Agric. Res. Kafr El-Sheikh Univ.*, 36(2):206 – 209.
- Hegazi, A., N. R. Samra., E.E.T. El-Baz., B. M. Khalil and M.S. Gawish (2014). Improving fruit quality of Manfalouty and Wonderful pomegranates by using bagging and some spray treatments with gibberellic acid, calcium chloride and kaolin. *J. Plant Production, Mansoura Univ.*, 5 (5): 779 – 792.
- Jackson, M.L. (1967). *Soil Chemical Analysis*. Prentice Hall of India, New Delhi, p. 498.
- Jifon, J. L and J. P. Syvertsen (2003). Kaolin particle film application can increase photosynthesis and water use efficiency of Ruby Red grapefruit leaves. *J. Amer. Soc. Hort. Sci.*, 128:107 – 112.
- Kerns, D.L. and G.C. Wright (2000). Protective and yield enhancement qualities of kaolin on lemons. *Citrus and Deciduous Fruit and Nut Research Report* (publ. az1178), College of Agriculture and Life Sciences, the University of Arizona, Tucson, Arizona, 85721.
- Lal, N. and N. Sahu (2017). Management strategies of sunburn in fruit crops - A review. *Int.J. Curr. Microbiol. Appl. Sci.*, 6(6): 1126 – 1138.
- Lombardini, L., M.K. Harris and D.M. Glenn (2005). Effects of particle film application on leaf gas exchange, water relations, nut yield, and insect populations in mature pecan trees. *Hort Science*, 40(5):1376 – 1380.
- Melgarejo, P., J.J. Martinez, F. Hernandez, R. Martinez-Font, P. Barrows and A. Erez (2004). Kaolin treatment to reduce pomegranate sunburn. *Scientia Horticulture*, 100(1 - 4): 349 – 353.
- Moran, R. and D. Porath (1980). Chlorophyll determination in intact tissues using N, N dimethyl formamide. *Plant Physiol.*, 65:478-479.
- Murphy, J. and J.R. Riley (1962). A modified single solution method for the determination of phosphorus in natural water. *Anal. Chem., Acta*, 27: 31-38.
- Palitha, W.J., M. Magdalena and J. Rogers (2010). The effect of maturity, sunburn and application of sunscreen on the internal and external qualities of pomegranate fruit grown in Australia. *Scientia Hort.*, 124: 57 – 61.
- Pregl, F. (1945). *Quantitative Organic Microanalysis*, 4th Ed J.A. Churchill, Ltd, London.
- Schrader, L.E., J. Sun, J. Zhang, D. Felicetti and J. Tian (2008). Heat and light-induced apple skin disorders: causes and prevention. *Acta Hort.*, 772: 51 – 58.
- Schupp, J.R., E. Fallahi and J.K. Chun (2002). Effect of particle film on fruit sunburn maturity and quality of ‘Fuji’ and ‘Honeycrisp’ apple. *Hort Technology*, 12(1): 87 – 90.
- Snedecor, G.W. and W.G. Cochran (1990). *Statistical methods*. 7th Ed. Iowa State Univ. Press. Ames., Iowa, USA, 593p.
- Sotelo-Cuitiva, Y.M., H. Restrepo-Diaz, A. Garcia-Castro, A. Ramirez-Godoy and V.J. Florez-Roncancio (2011). Effect of kaolin film particle applications (Surround WP®) and water deficit on physiological characteristics in rose cut plants (*Rose spp* L.). *American Journal of Plant Sciences*, 2:354 358.

Effect of kaolin foliar on fruit sunburn, yield and fruit quality of persimmon trees

- Stanley, D. (1998). Particle films: A new kind of plant protectant. *Agricultural Research*, 46(11): 16 – 19.
- Vatandoost, S., G.H. Davarynejad and A. Tehranifar (2014). Would kaolin particle film avoid sunburn in “Ardestani “pomegranate? *Advances in Environmental Biology*, 8(12): 607 – 610.
- Weerakkody, P., J. Jobling, M.M. Infante and G. Rogers (2010). The effect of maturity, sunburn and the application of sunscreens on the internal and external qualities of pomegranate fruit grown in Australia. *Scientia Horticulturae* 124:57 – 61.
- Yazici, K. and L. Kaynak (2009). Effects of kaolin and shading treatments on sunburn on fruit of Hicaznar cultivar of pomegranate (*Punica granatum* L. cv. Hicaznar). *Acta Horticulture*, 818:167 – 174.

تأثير الرش بالكاولين على نفحة الشمس و المحصول و جودة ثمار أشجار الكاكي

هشام محمد عبد الحميد ابو عجيلة

قسم اشجار الفاكهة متساقطة الاوراق - معهد بحوث البساتين - مركز البحوث الزراعية- الجيزة- مصر

المخلص العربي

أجريت تجربة حقلية خلال مواسم 2016 و 2017 في مزرعة خاصة في مركز أبو المطامير ، بمحافظة البحيرة ، مصر ، لدراسة تأثير الرش بمادة الكاولين بتركيزات 0 ، 2 ، 3 و 4 % مرتين أو ثلاث مرات في 15 يونيو و15 يوليو و15 أغسطس على الحالة الغذائية ، والنسبة المئوية للثمار المصابة بلفحة الشمس ، والمحصول وجودة ثمار الكاكي صنف كوستاتا.

أظهرت النتائج المتحصل عليها أن رش الكاولين بتركيز 4% مرتين أو ثلاث مرات والتي تعتبر أفضل المعاملات لتحسين الحالة الغذائية لأشجار الكاكي. علاوة على ذلك ، كانت معاملات الرش الورقي بالكاولين فعالة في التحكم في خفض النسبة المئوية للإصابة بلفحة الشمس وكذلك شدة الإصابة مقارنة بالأشجار غير المعاملة. كما أوضحت النتائج أن رش الكاولين ثلاث مرات قد أدى الى خفض درجة حرارة سطح الورقة والثمار خاصة عند الرش بتركيزات 3 و 4%. بالإضافة إلى ذلك ، قد أدت معاملات الكاولين إلى زيادة المحصول وتحسين جودة الثمار من حيث الوزن والحجم والطول وقطر الثمار. كذلك قد أدى رش الكاولين الي زيادة قيم $SSC\%/ acid ratio$ في الثمار مقارنة بثمار الأشجار الغير معاملة. ، لذلك يمكن التوصية باستخدام رش الكاولين بنسبة 4% ثلاث مرات خلال شهر (يونيو، يوليو، أغسطس) حيث انها أعطت أفضل النتائج في تحسين الحالة الغذائية للأشجار كما كان له تأثير ايجابي على تقليل أصابة الثمار بلفحة الشمس مع زيادة المحصول وتحسين جودة ثمار اشجار الكاكي صنف "كوستاتا".

السادة المحكمين

أ.د/ جهاد بشرى يوسف ميخائيل كلية الزراعة - جامعة كفر الشيخ

أ.د/ محمد على محمد سليمان مركز البحوث الزراعية - الجيزة

Effect of kaolin foliar on fruit sunburn, yield and fruit quality of persimmon trees