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Reducing Fruit Sunburn and Splitting in Murrcot Tangarine Fruits by Using Silicate Application

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Abstract

This experiment was done during 2019 and 2020 seasons on 10 years old Murcott tangerine trees (*Citrus reticulata*, Blanco) grafted on Volkamer lemon rootstock and grown under drip irrigation system at 3 × 5 m apart at a private citrus orchard at Sharkia Governorate, Egypt. The treatments were, Control treatment (sprayed with tape water only), Potassium silicate at 0.6 % (6 ml/ l), Aluminum silicate (Kaolin) at 4 %, Potassium silicate at 0.3 % (3 ml/ l) + Aluminum silicate (Kaolin) at 2 %. The treatments were done at 3 weeks intervals from mid-May to mid-August. The spraying was over the whole tree (canopy and fruits). Generally, all silica treatments improved yield, fruit quality and reduced sunburned and splitted fruits. The combined treatment of kaolin at 2 % + potassium silicate at 0.3 % (3 ml/ l), was the best treatment. Where, it reduced the sunburned and splitted fruits and improved yield, fruit weight, fruit dimensions, peel thickness, TSS% in comparison with other treatments. It could be recommended as a treatment for Murcotte tangarine trees.

Keywords: Sunburn, Spliting, Murcotte, Tangarine, Quality, Silica

1 Introduction

Citrus ranked in the third place among fruit crops after grapes and apples all over the world fruit production. It is one of the most cash crops generally in the world and especially in Egypt. Citrus ranked first between all fruit crops in Egypt. The areas grown with citrus in Egypt has increased through the last few decades, the fruiting area reached 429778.6 fed. producing about 4388325 tons with average of 10.21 tons/ fed. Tangerine (*Citrus reticulata*, Blanco) is one of the most substantial citrus species. Total fruiting areas of mandarin and tangerine varieties occupy 109609.5 fed. output 1038753 tons with 9.48 tons/fed on average, representing 25.5% of total citrus production, according to (FAO statistics 2018).

Generally, mandarine (*Citrus reticulata*, Blanco) occupies an important place among citrus trees grown in Egypt; due to it has good productive ability, easy peel, acceptable taste and quality.

Murcott Tangarine, came out of the department of agriculture, citrus breeding program in Florida, USA around 1916. It is a cross between a tangerine and sweet orange (Futch and Jackson 1993).

Silicon, role in biology of fruit as a nutrient element in trees plants is still limited. Many previous studies mentioned that Silicon treatments generally improved and enhance growth of plant (Alvrez and Datnoff 2001). Also, Silicon has an important role to play in helping plants to resist different stresses (Ma 2004; Tahir et al 2006). Potassium silicate (silicate in soluble form to use in agriculture field) allow plants to overcome drought by reducing water loss and help to increase yield and level of plant growth (Miyakeand Takahashi 1983 & 1986).

During the fruit growth period especially in summer months Murcotte tangerine fruits exposed to high temperature and high solar radiation which cause heat stress. Air temperature in summer normally reach above 40 °C. Fruit surface temperature may increase to be higher than air temperature in the same place (Parchomchuk and Meheriuk 1996).

The direct sunlight may cause sunburn damage. One of the heat stress symptoms is sunburn; it is a black spots or areas on the fruit skin. Sunburned fruits are unmarketable and commercially are unacceptable so, it is considering a loss in the harvested yield. (Melgarejo and Martinez 1992). Sunburn causes economic losses in a lot of fruits (Mango, pomegranate and apple) (Schrader et al 2003). So, there is an urgent need to find a method or a culture practices to reduce or avoid the incidence of fruit sunburn.

Due to the climatic change in the form of global warning and the contentious increasing of UV-B to earth, there is an increasing probability the percentage of sunburn disorder in fruits (Kerr and McElroy 1993).

Kaolin is a normal mineral, the major constituent is kaolinite (Aluminum silicate, $Al_2Si_2O_5(OH)_4$. Kaolin application have been used in various fruit types to reduce the infection of fruits and improved of yield and quality of fruits (Kerns and Wright 2000; Alvarez et al 2015). Previous studies suggested spraying the canopy of fruit trees with different materials to reduce sunburn by covering the canopy with a particle film. The covering film on fruits and leaves reflect sunlight. The reflection of sunlight reduces the temperature of fruits and leaves surface. This reduction reduces occurrence of sun burning fruits (Glenn 2009 & 2012).

The target of this research is to study the effect of Silicate applications (kaolin and potassium silicate) in different types and concentrations on reducing number of splitting and sunburned fruits and improving fruit quality of Murcotte tangerine trees.

2 Materials and Methods

During 2019 and 2020 seasons, 10 years old Murcott tangerine (*Citrus reticulata*, Blanco) trees. Examined trees grafted on Volkamer lemon rootstock in sandy soil at 3 × 5 m apart under drip irrigation system in a private citrus orchard established in Sharkia Governorate, Egypt. The tested trees were approximately similar in health and growth vigor and exposed to the normal agricultural practices followed in the commercial citrus orchards in this region. Trees sprayed by (Kaolin or/ and potassium silicate) at 3 weeks intervals starting from mid-May to mid-August. The spraying was over the whole tree (canopy and fruits). After drying the spraying materials on Murcotte trees it forms a loose white residue friable film on all leaves and fruits, without affecting the Co_2 exchange or blocking stomata (Glenn et al 1999). The plants were sprayed with potassium silicate $K_2Si_2O_5$ (11% Si and 60% K_2O) solution at (6 ml/l) as foliar application. Kaolin is a natural mineral, the main constituent is kaolinite (Aluminum silicate, $Al_2Si_2O_5(OH)_4$) was sprayed at 4%.

The experiment included 4 foliar application treatments as follows:

1- Spraying with tape water only as a control
2- Potassium silicate (11% Si and 60% K_2O) solution at 0.6 % (6 ml/ l)
3- Aluminum silicate (Kaolin) at 4%
4- Potassium silicate at 0.3 % (3 ml/ l) + Kaolin at 2%

These treatments were arranged in a randomized complete block design with five replicates each treatment replicate represented by one tree. The responses to the applied treatments were tested using the following fruiting properties:

2.1 Fruit yield

At the commercial harvesting date of Murcott tangerine fruits were picked out in the first week of February, the number of harvested fruits per tree and its weight were determined.

2.2 Fruit sunburn percentage

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

$$\text{Sunburned fruits \%} = \frac{\text{Number of sunburned fruits /tree}}{\text{Total number of fruits/ tree}} \times 100$$

2.3 Splitted fruits percentage

Splitted fruits were counted and splitted fruits percentage was calculated by using the following equation:

$$\text{Splitted fruits \%} = \frac{\text{Number of splitted fruits /tree}}{\text{Total number of fruits/tree}} \times 100$$

2.4 Fruit physical properties

Fivteen fruit per each replicate for each treatment were taken randomly. The studied parameters involved: Average fruit weight (g), fruit length (cm), fruit diameter (cm), peel thickness (mm) was estimated by using a Vernier caliper and fruit shape index; *i.e.*, length/diameter was determined.

2.5 Some of fruit juice's chemical components

Ten fruits from each replicate were juiced in electrical blender to calculate the total soluble solids percentage (TSS) with using a hand refractometer, total titratable acidity percentage as g citric acid/100 ml juice by titration against 0.1 N sodium hydroxide solution in the presence of phenolphthalein, the TSS/ acid ratio was calculated, vitamin C content as mg ascorbic acid/ 100 ml juice was measured by titration against 2, 6-dichloro phenol-indophenol dye according to the method described in the (AOAC 2006).

Statistical Analysis Method

The tabulated results were subjected to statistically analysis of variance by randomize complete block design with 5 replicates/ treatment according to (Snedecor and Cochran 1980) using Co-Stat program, and mean separation were done according LSD at 0.05 % level.

3 Results and Discussion

3.1 Fruit yield (Kg/ tree)

Achieved data in **Table 1**, clear that tested treatments improved yield significantly in the two tested seasons in comparison with control treatment. Treatment of aluminum silicate and potassium silicate together get the highest yield in both seasons, followed in a descending order by the treatment of potassium silicate individually. While control treatment recorded the lowermost yield in both seasons. The obtained results are in the same trend of Ibrahiem and Al-Wasfy (2014); El-Khawaga and Mansour (2014). The obtained increase in yield may be as a result of reducing the canopy temperature which improve net photosynthesis by reduction stomata closure during high temperature and reducing the respiration rate (Glenn et al 2001).

3.2 Sunburned fruits number and percentage

Results in **Table 1**, illustrate that all tested treatments clearly decreased sunburned fruits significantly in both seasons. The treatment of aluminum silicate and potassium silicate recorded the lowest values of sunburned fruits (20.1 and 20.8 fruit/tree) with percentage of 5.07 and 4.91 % respectively, in both seasons. The Kaolin treatment came in the second rank (32.6 and 26.9 fruit/tree) with percentage of 7.29 and 6.08 % in both seasons, respectively.

Generally, the combined treatment decreased sunburned fruits with an average of 16.60 and 14.8 % respectively, in both seasons compared with control treatment with an average of 15.7 % for the tested seasons. The highest number of sunburned fruits (93.3 and 78.5 fruit/tree) were recorded by control treatment with percentage of 21.6 and 19.8 % respectively, in both seasons. The other treatments recorded in between values. The obtained results are in accordance with Melgarejo et al (2004) who found that kaolin treatment reduce number of sunburned fruits as a result of coating the fruits with a white film that reduce the temperature of leaf and fruits. In the same line, Glenn *et al* (2002) also, found that the covering film on fruits and tree canopy reflects UVA radiation which reduces sunburn. Moreover, reduction in sunburned fruits could be as a result of reducing heat stress (Chabbal et al 2014). Aziz et al (2002), mentioned that spraying silicon forming a double lay on plant different tissues that protect trees parts from different stresses. Also, silicon act as an antioxidant factor that help to protect cells from senescence, aging and prevent reactive oxygen species from stopping the permeability function of cell walls (Ma 2004; Tahir et al 2006).

3.3 Splitted fruits numbers and percentage

Data in **Table 1**, clear that all tested treatments reduced number of splitted fruits/ tree in the two studied seasons. Aluminum and potassium silicate treatments together recorded the lowest values of splitted fruits/ tree (9.17 and 11.5 fruit/tree) with percentage of 2.32 and 2.71 %, respectively in both seasons, without significant variations with the treatment of potassium silicate only. Control treatment registered the highest values of splitted fruits/tree (25.1 and 29.1 fruit/tree) with percentage of 5.81 and 7.34 % respectively, in both seasons. The other treatments came in between values. The treatments of potassium silicate and aluminum silicate individually ranked the second in both seasons without significant difference between them. Generally, the treatment of aluminum silicate and potassium silicate together decreased splitted fruits by 15.9 and 17.6 % respectively, in both seasons, with an average 16.8 % for both seasons. The achieved results of the promotive effect of aluminum and potassium silicate together in reducing number of splitting fruits as a resalts of its role in reducing heat stress and the temperature of fruits surface (Glenn et al 2002; Glenn 2009; Chabbal et al 2014).

3.4 Fruit physical properties

Data in **Table 2**, show that the tested treatment improved fruit weight significantly in the second season only and insignificantly in the first season. The combined treatment recorded the highest fruit weight (197.3 g) without significant differences with those treated with Kaolin and Potassium silicate. Moreover, data in **Table 2**, show that fruit dimensions (cm) were influenced significantly by the tested treatments in both seasons. The treatment of aluminum silicate and potassium silicate together and the treatment of aluminum silicate individually recorded the highest fruit dimensions in both seasons without significant differences between them. While, control and Potassium silicate treatments gained the lowermost values of fruit dimensions without significant differences between them. In addition, data in **Table 2,** cleared that the tested treatments affect fruit shape index insignificantly during both seasons. It is obvious from **Table 2**, that all tested treatments enhanced significantly peel thickness in both seasons. The treatment of aluminum silicate and potassium silicate together gained the highest peel thickness in both seasons (2.87 and 2.91 mm) respectively, followed by the treatment of Kaolin. Control treatment gained the lowermost peel thickness. The treatment of potassium silicate ranked in the second place in the examined seasons. The significant impact of the tested treatments on fruit length, diameter and peel thickness is in line with Palitha et al (2010); Hegazi et al (2014); Ennab et al (2017).

Table 1. Effect of foliar applications of aluminum silicate (kaolin) and potassium silicate on yield, total number of fruits/ trees, burned fruits/tree and its percentage, splitted fruits/tree and its percentage of Murcotte tangerine fruits during 2019 and 2020 seasons

Treatments	Yield/tree (Kg)		Total number of fruits/ trees		No. of sunburned fruits/tree		Sunburned fruits/tree %		No. of splitted fruits		Splitted fruits %	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Control (water spraying)	76.8	71.9	432.1	396.4	93.3	78.5	21.6	19.8	25.1	29.1	5.81	7.34
Potassium silicate at 0.6% (6 ml/ l)	80.7	78.2	454.0	381.6	66.7	58.8	14.7	15.4	21.0	19.5	4.63	5.11
Aluminum silicate (Kaolin) at 4 %	83.4	81.6	447.2	442.1	32.6	26.9	7.29	6.08	12.2	16.0	2.73	3.62
Potassium silicate at 0.3% (3 ml/l) + Aluminum silicate (Kaolin) at 2 %	87.5	84.3	396.0	423.8	20.1	20.8	5.07	4.91	9.17	11.5	2.32	2.71
LSD at 0.05	2.85	1.95	8.77	6.37	7.27	9.57	2.49	2.34	9.43	8.13	2.60	2.00

Table 2. Effect of foliar applications of aluminum silicate (kaolin) and potassium silicate on some fruit physical properties of Murcotte tangerine fruits during 2019 and 2020 seasons

Treatments	Fruit weight (g)		Fruit length (cm)		Fruit diameter (cm)		Fruit shape index		Peel thickness (mm)	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Control (water spraying)	169.5	176.4	5.30	6.41	7.00	8.10	0.76	0.79	2.02	2.11
Potassium silicate at 0.6 % (6 ml/ l)	171.3	182.6	5.36	6.47	7.06	8.21	0.76	0.79	2.30	2.19
Aluminum silicate (Kaolin) at 4 %	180.2	190.6	5.51	6.83	7.61	8.73	0.72	0.78	2.63	2.68
Potassium silicate at 0.3 % (3 ml/l) + Aluminum silicate (Kaolin) at 2 %	181.4	197.3	5.72	7.11	7.84	8.92	0.74	0.80	2.87	2.91
LSD at 0.05	NS	17.7	0.31	0.38	0.53	0.82	NS	NS	0.22	0.35

3.5 Fruit chemical constituents

Data shown in **Table 3**, indicate that, the studied treatments affected chemical fruit quality (TSS %, titratable acidity and TSS/acid ratio) significantly, in both seasons. The treatment of aluminum silicate and potassium silicate together increased TSS% significantly, in both seasons, while the control recorded the lowermost value of TSS% in both seasons. Concerning titratable acidity, control and potassium silicate treatments recorded the highest acidity % in both seasons, While treatment of aluminum silicate and potassium silicate as well as Kaolin only gained the least value of acidity % in both seasons. TSS/acid ratio was in the same trend of acidity. The recorded data are in line with Ibrahiem and Al-Wasfy (2014); El-Khawaga and Mansour (2014). The tested treatments clear insignificant effect concerning vit. C content in 2019 and 2020 seasons.

Table 3. Effect of foliar applications of aluminum silicate (kaolin) and potassium silicate on TSS%, titratable acidity, TSS/acid ratio and Vit. C of Murcotte tangerine fruits during 2019 and 2020 seasons

Treatments	TSS (%)		Titratable acidity (%)		TSS/acid ratio		Vit. C (mg /100 ml)	
	2019	2020	2019	2020	2019	2020	2019	2020
Control (water spraying)	10.23	12.07	1.42	1.34	7.20	9.01	39.4	38.7
Potassium silicate at 0.6 % (6 ml/ l)	10.75	12.13	1.40	1.31	7.68	9.26	40.7	40.4
Aluminum silicate (Kaolin) at 4 %	12.13	13.13	1.00	0.98	12.13	13.40	42.5	41.8
Potassium silicate at 0.3% (3 ml/l) + Aluminum silicate (Kaolin) at 2 %	12.90	13.81	0.96	0.92	13.44	15.01	43.8	42.6
LDS at 0.05	0.78	0.59	0.19	0.27	1.82	2.90	NS	NS

4 Conclusions

The combined treatment of aluminum silicate and potassium silicate together get the highest yield, recorded the lowest values of sunburned fruits and the lowest values of splitted fruits/ tree, in both seasons compared with control treatment. It could be concluded that, the used materials (Silicate) may play as a screen or provide a shade for Murrcot fruits to protect it from the direct sunlight by reflect it. The combined treatment of kaolin at 2 % + potassium silicate at 0.3 % (3 ml/ l), was the best treatment and it could be recommended as a treatment for Murcotte tangarine trees.

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تقليل الثمار المصابة بلفحة الشمس والتشقق في ثمار يوسفى ميركوت باستخدام السيليكات [30]

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الموجـــــــز

أجريت هذه الدراسة خلال موسمي 2019 و2020 على أشجار يوسفي ميركوت عمرها 10 سنوات ومطعومه على أصل الليمون الفولكاميريانا والنامية تحت نظام الرى بالتنقيط وعلى مسافات 3×5 م فى أحد حدائق الموالح الخاصة بمحافظة الشرقية، مصر. تم معاملة الأشجار بأربعة معاملات وهي: معاملة المقارنة (الرش بالماء فقط)، المعاملة بسلكيات البوتاسيوم بتركيز 0.6% (6 مل/لتر)، المعاملة بسليكات الألومنيوم (الكاولين) بتركيز 4 %، المعاملة بسليكات البوتاسيوم بتركيز 0.3% (3 مل/ لتر) وسليكات الألومنيوم (الكاولين) بتركيز 2% معا، رشا على المجموع الخضرى والثمار. تم تكرار المعاملات على فترات كل 3 أسابيع ابتداء من منتصف مايو وحتى منتصف أغسطس. أدت معاملات السيليكا بصفة عامة الى تحسين صفات المحصول وجودة الثمار وتقليل عدد الثمار المصابة بلفحة الشمس والتشقق. ووجد ان المعاملة بسيليكات الألومنيوم (2%) (الكاولين) وسيليكات البوتاسيوم 0.3% (3 مل/ لتر) معا كانت أفضل معاملة حيث أدت الى تقليل عدد الثمار المصابة بلفحة الشمس والتشقق الى اقل عدد ممكن مع تحسين صفات المحصول وحجم الثمرة وابعادها وكذلك سمك القشرة والنسبة المئوية للمواد الصلبة الذائبة بالمقارنة بالمعاملات الأخرى ولذلك ينصح بمعاملة أشجار اليوسفى الميركوت بها.