

## Effect of reflective particles spraying on productivity and quality of “Anna” apple *Malus domestica*

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### ABSTRACT

This work was carried out through 2018 and 2019 seasons on “Anna” apple (*Malus domestica*). Trees were 5 years old, grown in sandy soil and planted at 2 x 3 meters apart under drip irrigation system. This investigation aimed to enhanced production and fruit quality of the Anna” apple (*Malus domestica*). Trees sprayed with Kaolin at 6%, potassium silicate at 3% and calcium carbonate at 3 % in three different spraying dates i.e. (first May - first June - first July). Results proved that spraying with potassium silicate at 3% + calcium carbonate at 3% at in first June spraying date treatment gave the highest leaf area, total chlorophyll, yield and fruit quality of Anna” apple tree. In addition, the interaction between reflective particles spraying treatments and spraying dates recorded significant highest values of Anna apple fruit parameters in both seasons. On the other hand, trees untreated recorded the lowest yield and fruit quality during two studied seasons.

**Keywords:** Anna” apple (*Malus domestica*), Kaolin, potassium silicate, fruit quality

### Introduction

Climate change is undoubtedly the most imminent environmental issue the world is facing today. The rise in climate temperature will have certain major effects on ecosystems, wildlife, food chains and eventually human life (Appels *et al.*, 2011). Sunburn injury is common on fruits due to high solar radiation levels and air temperatures and low relative humidity. Excess absorbed energy is the greatest contributor to cell death and sunburn. The incidence and severity of sunburn depends upon climatic factor, cultivars, hormonal, nutritional and soil moisture (Schrader *et al.*, 2003a). The damage caused due to sun burning ranges from 0.9-19.13% in different varieties (Singh *et al.*, 2012).

Sunburn is a physiological disorder of apple fruit “Anna” apple (*Malus domestica*) caused by Stress caused by high temperatures, high flux densities of solar radiation. Excess solar radiation may have a direct effect or its effect may be indirect through an increase in radiant heating (Schrader *et al.*, (2001, 2003a). The use of reflective particles on fruits has been suggested as a tool to diminish its thermal charge because it reduces the incident radiation that can be absorbed by the fruits (Glenn *et al.*, 2002; 2003, 2009; Wuncshe *et al.*, 2004) and thus reduce the incidence of sunburn (Glenn *et al.*, 2002; Gindaba and Wand, 2005; Wand *et al.*, 2006; Colavita, 2011). The nature of particles generally comprises minerals of high reflectivity, among them kaolin and calcium carbonate are alternatives of relative low cost, safe use, low erosion, reduced particle size and water diffusion ability (Glenn *et al.*, 2003 and Melgarejo *et al.*, 2004) on pomegranate fruits. When the effectiveness of the products is expressed in terms of damaged fruit, it is influenced by the sensitivity of the variety, growing conditions and application method (Glenn *et al.*, 2002; Erez and Glenn, 2004). Among the numerous culture practices developed to control sunburn in various crops using kaolin and Calcium carbonate, particle film applications by spraying canopies with a suspension of different types of clay along with kaolin Calcium Carbonate, leaving a film on the leaves and fruits, which reflect sunlight this led to lower the temperature of leaf surface and fruits thereby reducing sunburn and improving fruit quality (Glenn and Puterka, 2005; Glenn, 2009 and Weerakkody *et al.*, 2010). Kaolin clay and Calcium carbonate is a natural mineral which main constituent is kaolinite ( $Al_2Si_2O_5(OH)_4$ ). Kaolin clay treatments have been successfully applied in different fruit species to minimized fruit sunburn and improve vegetative growth, yield and fruit quality (Kerns and Wright, 2000; Colavita *et al.*, 2011; El-Said, 2015. and Alvarez *et al.*, 2015).

Potassium silicate is a source of highly soluble potassium and silicon. It is used in agricultural production systems primarily as a silica amendment and has the added benefit of supplying small

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amounts of potassium. In many horticultural crops, adequate potassium nutrition also contributes in enhancing tree yields, fruit size, fruit colour, soluble solids, ascorbic acid concentrations, shelf life and also improved and shipping quality (Kanai *et al.*, 2007). Furthermore, Gad El- Kareem *et al.*, (2014) and Hattori *et al.*, (2005) they mentioned that the essential roles of silicon (Si) on promotion growth and fruiting of Zaghoul date palm. Also, potassium silicate play important role as sunscreen protective film that acts as a superior reflective particle barrier to the harmful effects of solar radiation and water stress potassium silicate is considered as an important beneficial element as it helps in growth and development of plant.

So, the aim of this study is to investigate the effect of kaolin, Potassium silicate and Calcium Carbonate application in different times on reducing sunburn and improving productivity and fruit quality of Ann apple trees.

### Material and Methods

Studies were conducted during 2018 and 2019 seasons on 5 years old ‘Anna’ apple cultivar, grown in a sandy soil in a private farm located at Km 85, Cairo – Alex. Desert Road. The trees in this experiment planted at 2×3m spacing. Physical and chemical analysis of the experimental soil shown in Table 1, meanwhile the chemical analysis of used water from irrigation is recorded in (Table 2). The Experiment was designed as a split plot design, seven spraying treatments was assigned in the main plot (Control - Kaolin 6% (A) - K silicate 3% (B) - Ca carbonate 3% (C) - A + B - A + C - B +C) While, spraying dates was assigned in the sub plot with three treatments i.e. (first May – first June – first July). Each treatment replicated thrice with two trees in each replicate. All tested trees were healthy, nearly uniform vigor and irrigated by drip irrigation system. At the second week of August the parameters of vegetative growth i.e. leaf area (was determined by using portable area planimeter Mod Li3100 Ali (Li-Cor)) and leaf total chlorophyll content (in the field by using Minolta chlorophyll meter SP AD-502) was measured. At harvest time (August), the following parameters were recorded; fruit yield kg/tree = number of fruit/tree X fruit weight per g (the fruits were harvested as soon as they reached the maturity indices and a number of fruits per tree was counted and then weighted in g and recorded), physical properties i.e. fruit length, diameter (cm), volume (cm<sup>3</sup>) and fruit shape index. Chemical properties i.e. total soluble solids (TSS %) and total acidity (%) were determined according to method A.O.A.C., (2005) and finally, marketable fruits (At harvest time (August) in both seasons, normal and sunburned fruits from all treatments were counted .Thereafter; the percentage of sunburned fruits was calculated). The obtained data were statistically analyzed according to Snedecor and Cochran (1990). Duncan's Multiple Range test effect was used to compare treatment means Duncan (1955).

**Table 1:** Analysis of experimental soil in 2018 and 2019 seasons.

#### Physical analysis:

Soil Depth (cm)	Particle size distribution				Texture class	Bulk Density (g/cm)	Organic matter (%)	Moisture content (%)	
	Coarse sand	Fine sandy	Silt	Clay				Field Capacity	Wilting Point
0-30	0.0	97.50	1.50	1.00	sand	1.52	0.20	9.21	4.44
30-60	0.0	98.00	1.40	0.60	sand	1.56	0.19	8.88	4.49

#### Chemical analysis:

Soil Depth (cm)	CaCO <sub>3</sub>	pH Soil past	ECe (dSm <sup>-1</sup> )	Soluble cations (meq/l)				soluble anions (meq/l)			
				Ca <sup>++</sup>	K <sup>+</sup>	Na <sup>+</sup>	Mg <sup>++</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>=</sup>	HCO <sub>3</sub> <sup>-</sup>	CO <sub>3</sub> <sup>=</sup>
0-30	4.1	7.1	1.8	3.1	1.5	11	1.8	9.5	5	1.1	-
30-60	4.2	7.1	1.4	2.8	1.4	10.2	1.3	8.5	4.5	1.2	-

**Table 2:** Chemical analysis of water used for irrigation in 2018 and 2019 seasons.

pH	EC	O.M (%)	Soluble cations (meq/l)				soluble anions (meq/l)			
			Ca <sup>++</sup>	Mg <sup>++</sup>	Na <sup>+</sup>	K <sup>+</sup>	CO <sub>3</sub> <sup>=</sup>	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>=</sup>
7.00	0.6	0.8	1.8	1.2	0.6	0.9	0.0	1.8	2.6	0.1

## Results and Discussion

### 1. Leaf Area

Regarding the effect of spraying “Anna” apple trees with the reflective particle kaolin potassium silicate and calcium carbonate on leaf area, the data presented in (Table 3) Comparison between the treatments means for leaf area indicated that, spraying K silicate + Calcium carbonate treatments recorded the highest leaf area (37.5 and 38.0 ) respectively, in first and second seasons . On the other hand, the application of treatments in the second date (first June) gave the maximum values of leaf area (38.3 and 39.0) in both seasons, respectively. The interaction between treatments and application dates was enhancement leaf area and gave the highest values in two seasons. The variation ranged from 33.1 to 41.1 in the first season and between 32.6 to 41.4 in the second season, respectively.

### 2. Total chlorophyll

Data represented in (Table 3) showed that, all Anna apple trees sprayed treatments as reflective particle in three spraying dates were significant in leaf total chlorophyll as compared to the control in 2018 and 2019 seasons. Furthermore, comparison among the treatments means for total chlorophyll indicated that spraying the reflective particle potassium silicate at 3% + calcium carbonate at 3% concentration treatments gave the highest apple total chlorophyll (54.9 and 56.7) in both season, respectively. Also, the spraying of treatments in the second date gave the maximum apple total chlorophyll (55.5 and 57.2) in both seasons, respectively. The interaction between treatments and application dates was significant increase compare with control, while, the highest and best results were recorded on Anna treated apple trees by potassium silicate at 3% + calcium carbonate at 3% in first June (second spraying date) (58.7 and 62.0), respectively in two studied seasons. Meanwhile, trees untreated recorded the lowest total chlorophyll during two seasons of studied.

**Table 3:** Effect of some reflective particles spraying; spraying dates and their interaction on leaf area (cm<sup>2</sup>) and total chlorophyll of Anna apple trees during 2018 and 2019 seasons.

Treatment	1 <sup>st</sup> Season				2 <sup>nd</sup> Season			
	1/5	1/6	1/7	Mean	1/5	1/6	1/7	Mean
	<b>Leaf area (cm<sup>2</sup>)</b>							
Control	33.3 e-g	33.5 e-g	33.1 e-g	33.3 D	32.8 d	33.8 d	32.6 d	33.1 C
Kaolin 6% (A)	35.0 c-g	37.3 a-f	32.2 g	34.8 C	35.8 b-d	38.2 a-d	32.6 d	35.5 B
K silicate 3% (B)	35.8 c-g	38.6 a-d	33.5 e-g	36.0 BC	36.6 a-d	40.0 ab	33.2 d	36.6 AB
Ca carbonate 3% (c)	35.6 c-g	37.9 a-e	33.0 fg	35.5 BC	36.3 a-d	38.7 a-c	32.7 d	35.9 B
A + B	36.5 b-g	40.2 ab	34.1 d-g	36.9 AB	36.5 a-d	40.2 ab	34.4 cd	37.1 AB
A + C	36.1 b-g	39.3 a-c	33.8 e-g	36.4 AB	36.7 a-d	40.7 ab	34.3 cd	37.2 AB
B + C	37.0 b-f	41.1 a	34.5 d-g	37.5 A	37.3 a-d	41.4 a	35.4 b-d	38.0 A
Mean	35.6 B	38.3 A	33.5 C		36.0 B	39.0 A	33.6 C	
	<b>Leaf total chlorophyll</b>							
Control	49.8 lm	50.5 j-l	49.8 lm	50.0 G	50.1 j-l	49.5 kl	48.8 l	49.5 E
Kaolin 6% (A)	52.2 hi	54.8 d	49.3 m	52.1 F	53.7 gh	56.6 d-f	48.8 l	53.0 D
K silicate 3% (B)	53.0 fg	56.0 c	50.1 k-m	53.0 D	54.8 fg	58.0 b-d	50.2 jl	54.3 C
Ca carbonate 3% (c)	52.6 gh	55.3 d	49.6 lm	52.5 E	54.3 g	57.0 c-e	52.3 hi	54.5 C
A + B	53.9 e	57.3 b	51.2 j	54.1 B	55.4 e-g	59.0 b	51.8 ij	55.4 B
A + C	53.5 ef	56.3 c	50.7 jk	53.5 C	55.2 e-g	58.5 bc	51.2 j-k	55.0 BC
B + C	54.2 e	58.7 a	51.8 i	54.9 A	55.7 e-g	62.0 a	52.3 hi	56.7 A
Mean	52.8 B	55.5 A	49.3 C		54.2 B	57.2 A	50.8 C	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

These results were in harmony with those obtained by El-Said, (2015) demonstrated that foliar applications with kaolin and CaCO<sub>3</sub> significantly increased vegetative growth characteristics. In addition, the pronounced promotional effect of the foliar application of kaolin on vegetative growth characteristics may be related to the direct effects of kaolin on plant resistance to both biotic and abiotic stress including drought (Glenn *et al.*, 2002). In addition, kaolin foliar application was reported to improve CO<sub>2</sub> assimilation under high temperature (Glenn *et al.*, 2002). Such gains can explain the enhancement of plant growth in associated with higher plant water content.

### 3. Productivity:

#### 3.1. No. of fruits/tree, fruit weight (g) and yield kg/tree

##### 3.1.1. No. of fruits/tree

Comparison between the treatments means no. of fruit/tree (Table 4) indicated that spraying potassium silicate at 3% + calcium carbonate at 3% concentration treatments gave the highest number of Anna apple fruit (52.4 and 57.0) in both studied season, respectively. Moreover, the application of treatments in the second date 1/6 (first June) gave the maximum number of apple fruit (50.9 and 57.0) in the first and second seasons 2018 & 2019, respectively. The interaction between spraying treatments and application (spraying) dates was significant and resulted highest apple no. of fruit/tree when treated trees by potassium silicate + calcium carbonate in 1/6 (first June) (55.7 and 61.7), respectively in both seasons. On the other hand, trees untreated recorded the lowest No. of fruit /tree during two seasons of studied.

**Table 4:** Effect of some reflective particles spraying; spraying dates and their interaction on No. of fruits/ tree, Fruit weight (g) and Yield/tree (kg) of Anna apple trees during 2018 and 2019 seasons.

Treatment	1 <sup>st</sup> Season				2 <sup>nd</sup> Season			
	1/5	1/6	1/7	Mean	1/5	1/6	1/7	Mean
<b>No. of fruits/ tree</b>								
Control	44.0 cd	44.7 e-d	42.3 d	43.7 C	47.7 cd	48.0 cd	46.0 d	47.2 D
Kaolin 6% (A)	45.7 b-d	50.0 a-d	45.3 b-d	47.0 B	49.7 b-d	56.7 ab	45.7 d	50.7 C
K silicate 3% (B)	47.3 a-d	50.3 a-d	49.0 a-d	48.9 B	49.7 b-d	57.7 ab	49.7 b-d	52.3 BC
Ca carbonate 3% (c)	47.0 a-d	50.3 a-d	46.3 b-d	47.9 B	49.0 b-d	56.0 ac	49.7 b-d	51.6 BC
A + B	47.7 a-d	52.7 a-c	48.3 a-d	49.6 B	51.3 b-d	61.0 a	49.0 b-d	54.0 B
A + C	47.3 a-d	52.7 a-c	47.7 a-d	49.2 B	50.7 b-d	57.0 ab	49.3 b-d	52.3 BC
B + C	47.7 a-d	55.7 a	54.0 ab	52.4 A	53.7 b-d	61.7 a	55.7 a-c	57.0 A
Mean	46.7 B	50.9 A	47.6 B		50.2 B	57.0 A	49.3 B	
<b>Fruit weight (g)</b>								
Control	132.3 e	133.3 e	134.0 e	133.2 D	127.0 d	126.3 d	128.0 d	127.1 D
Kaolin 6% (A)	136.7 e	170.3 b	134.3 e	147.1 C	133.7 cd	132.7 cd	126.3 d	130.9 D
K silicate 3% (B)	142.3 de	181.3 ab	139.0 de	156.4 B	140.3 b-d	147.7 a-c	135.7 cd	141.2 BC
Ca carbonate 3% (c)	141.0 de	178.7 ab	136.0 e	151.9 BC	136.7 cd	145.7 a-c	134.7 cd	139.0 C
A + B	153.0 cd	178.0 ab	139.0 de	156.7 B	144.3 a-c	155.0 ab	135.3 cd	144.9 AB
A + C	147.0 c-e	181.3 ab	137.0 e	155.1 B	141.3 a-d	152.3 ab	134.3 cd	142.7 BC
B + C	156.3 c	188.0 a	149.0 c-e	162.2 A	142.3 a-d	155.7 a	146.7 a-c	148.2 A
Mean	144.1 B	173.0 A	138.3 C		138.0 B	145.0 A	134.4 C	
<b>Yield/tree (kg)</b>								
Control	5.82 g	5.94 fg	5.69 g	5.82 E	6.05 fg	6.05 f-g	5.90 g	6.00E
Kaolin 6% (A)	6.24 e-g	8.52 bc	5.63 g	6.80 D	6.64 b-e	8.08 b-d	5.78 g	6.83 D
K silicate 3% (B)	6.74 e-g	9.47 ab	6.37 e-g	7.53 BC	6.97 d-g	8.25 bc	6.51 e-g	7.33 C
Ca carbonate 3% (c)	6.63 eg	8.99 ac	6.08 f-g	7.23 C	6.70 e-g	8.16 b-d	6.68 e-g	7.18 CD
A + B	7.29 d-f	9.37 ab	6.62 e-g	7.76 B	7.41 c-f	9.56 a	6.63 e-g	7.87 B
A + C	6.96 e-g	9.54 ab	6.53 e-g	7.68 B	7.16 d-g	8.68 ab	6.43 e-g	7.43 C
B + C	7.45 de	10.09a	8.06 cd	8.53 A	7.64 e-g	9.57 a	8.14 b-d	8.45 A
Mean	6.73 B	8.85 A	6.43 C		6.94 B	8.38 A	6.58 C	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

##### 3.1.2. Fruit weight (g)

Table, 4 shows that the all treatments kaolin, potassium silicate and calcium carbonate were gave high positive effect on fruit weight as compared to the control in 2018 and 2019 seasons. However, Comparison between the treatments means in the same table indicated that spraying potassium silicate at 3% + calcium carbonate at 3% concentration treatments gave the highest Anna apple fruit weight (162.2 and 148.2(g)) in both studied season, respectively. Regarding, the application of treatments in the second date 1/6 (first June) surpassed all treatments and gave the highest values of Anna apple fruit weight (173.0 and 145.0 (g)) in the first and second seasons 2018 & 2019, respectively. The interaction between spraying treatments potassium silicate + calcium carbonate and application spraying dates (second spraying date) were recorded the highest apple fruit weight (188.0 and 155.7 g) in both seasons, respectively. On the other hand, trees untreated recorded the lowest fruit weight during two seasons of studied.

### **3.1.3. Yield kg/tree (kg)**

Data in (Table, 4) demonstrates that Anna apple yield/tree increased significantly with spraying all treatments and gave the best values of yield (kg) in 2017 and 2018 seasons as compared with control. Moreover, Spraying treatments with potassium silicate + calcium carbonate was gave the high value of apple yield/tree (8.53 and 8.45kg) as compared with other treatments during the two seasons. Also, the spraying treatments in the second date 1/6 (first June) superior for all treatments and gave the highest values of Anna apple yield/tree (8.85 and 8.38 kg) in two seasons 2018 & 2019, respectively. However, the interaction between spraying treatments and spraying dates induced high positive effect and surpassed all treatment on the yield/tree (10.09 and 9.57 (kg)) by potassium silicate + calcium carbonate with second spraying date in both studied seasons, respectively.

The above results are in a harmony with that of Glenn and Puterka, (2005) These concluded that, increased fruit yield as a result of kaolin treatments may be due to its protective effect from high temperature and reflection of solar radiation, especially UV wavelengths, which led to reduce heat stress on fruits, enhance fruit water content by decreasing transpiration from fruit surface. Also, yield increased as a result of increased fruit number resulting to successfully protected fruits from med fly infestations, reduction fruit disorders and weight.

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## **4. Fruit physical properties**

### **4.1. Fruit length and fruit diameter**

The experiment results presented in (Table 5) showed that the improvement in fruit length and fruit diameter associated with most of reflective film treatments with all spraying dates as compared with control in both seasons. Furthermore, it appears from our results that the reflective particle film treatment increased the fruit length and fruit diameter of apple trees significantly and were gave the highest values in two treatments (potassium silicate + calcium carbonate) with the second spraying date (8.60 and 8.47cm) for fruit length and (7.47 and 7.17 cm) for fruit diameter in both seasons, respectively compared to the other treatments and control.

### **4.2. Fruit volume**

Data in (Table 5) showed that, reflective particles treatments, Kaolin at 6%, potassium silicate at 3% and calcium carbonate at 3% and their combination gave high positive effect on fruit volume compared with the control in 2018 and 2019 seasons. Regarding spraying date, second date had highest significant values in both studied seasons. However, potassium silicate + calcium carbonate in second spraying date ( 205.0& 178.3 ) was the most effective treatment and resulted in the highest significant fruit volume as the interaction between the two studied factors.

### **4.3. Fruit shape index**

Data in (Table 5) showed that, results of the two studied seasons had inconstant trend for reflective particles treatments, spraying dates and their interaction.

**Table 5:** Effect of some reflective particles spraying; spraying dates and their interaction on fruit length, diameter, volume (cm) and fruit shape index of Anna apple trees during 2018 and 2019 seasons.

Treatment	1 <sup>st</sup> Season			2 <sup>nd</sup> Season			Mean	
	1/5	1/6	1/7	1/5	1/6	1/7		
	<b>Fruit length (cm)</b>							
Control	7.17 de	7.27 de	7.1 e	7.18 D	7.30 c-e	7.30 c-e	6.97 e	7.19 D
Kaolin 6% (A)	7.30 de	7.67 de	7.23 de	7.40 C	7.33 c-e	7.53 c-e	7.20 de	7.36 CD
K silicate 3% (B)	7.43 de	7.93 b-d	7.60 de	7.66 AB	7.40 c-e	7.63 b-e	7.10 de	7.38 CD
Ca carbonate 3% (c)	7.33 de	7.83 c-e	7.30 de	7.49 BC	7.37 c-e	7.80 b-d	7.13 de	7.43 BC
A + B	7.47 de	8.40 ab	7.30 de	7.72 A	7.53 c-e	8.17 ab	7.23 c-e	7.64 AB
A + C	7.53 de	8.27 a-c	7.43 de	7.74 A	7.47 c-e	7.93 bc	7.10 de	7.50 BC
B + C	7.60 de	8.60 a	7.23 de	7.81 A	7.70 b-e	8.47 a	7.30 c-e	7.82 A
Mean	7.40 B	8.00 A	7.31 B	7.44 B	7.83 A	7.15 C		
	<b>Fruit diameter (cm)</b>							
Control	6.17 e-f	6.47 c-f	5.97 f	6.20 DE	5.97 fg	6.20 e-g	6.03 fg	6.07 C
Kaolin 6% (A)	5.97 f	6.50 c-f	5.97 f	6.14 E	6.00 fg	6.33 d-g	5.93 g	6.09 C
K silicate 3% (B)	6.10 e-f	6.73 b-d	6.13 e-f	6.32 CD	6.03 fg	6.53 c-e	6.47 c-f	6.34 B
Ca carbonate 3% (c)	6.07 e-f	6.57 c-e	6.00 f	6.21 DE	6.00 fg	6.40 d-g	6.17 e-g	6.19 C
A + B	6.27 c-f	7.00 b	6.33 c-f	6.53 B	6.10 e-g	6.83 bc	6.53 c-e	6.49 B
A + C	6.23 d-f	6.77 bc	6.37 c-f	6.46 BC	6.10 e-g	6.73 b-d	6.47 c-f	6.43 B
B + C	6.43 c-f	7.47 a	6.73 b-d	6.88 A	6.13 e-g	7.17 a	6.97 a-b	6.76 A
Mean	6.18 B	6.79 A	6.21 B	6.05 C	6.60 A	6.37 B		
	<b>Fruit volume (cm<sup>3</sup>)</b>							
Control	147.3 d-f	146.0 d-f	136.7 f	143.3 D	125.0 ef	130.0 d-f	123.3 f	126.1 E
Kaolin 6% (A)	149.7 d-f	161.7 d-f	137.3 f	149.6 CD	123.3 f	138.3 c-f	125.0 ef	128.9 DE
K silicate 3% (B)	154.0 d-f	169.3 c-e	144.0 ef	155.8 C	130.0 d-f	146.7 b-d	140.0 c-f	138.9 C
Ca carbonate 3% (c)	151.3 d-f	173.3 b-d	139.0 f	154.6 C	126.7 d-f	145.0 b-e	131.7 d-f	134.4 CD
A + B	157.7 d-f	191.7 ab	156.7 d-f	168.7 AB	133.3 c-f	160.0 b	143.3 b-f	145.6 B
A + C	157.7 d-f	185.0 bc	151.7 d-f	164.7 B	130.0 d-f	151.7 bc	140.0 c-f	140.6 BC
B + C	164.0 d-f	205.0 a	160.0 d-f	176.3 A	140.0 c-f	178.3 a	151.7 bc	156.7 A
Mean	154.5 B	176.0 A	146.5 C	129.8 C	150.0 A	136.4 B		
	<b>Fruit shape index</b>							
Control	1.16 ab	1.12 ab	1.19 ab	1.16 BC	1.22 a	1.18 a	1.16 ab	1.19 A
Kaolin 6% (A)	1.22 a	1.18 ab	1.23 a	1.21 A	1.22 a	1.19 a	1.21 a	1.21 A
K silicate 3% (B)	1.22 a	1.18 ab	1.24 a	1.21 A	1.23 a	1.17 ab	1.10 ab	1.16 A
Ca carbonate 3% (c)	1.21 ab	1.19 ab	1.22 a	1.21 A	1.23 a	1.22 a	1.16 ab	1.20 A
A + B	1.19 ab	1.20 ab	1.15 ab	1.18 AB	1.24 a	1.20 a	1.11 ab	1.18 A
A + C	1.21 ab	1.22 a	1.17 ab	1.16 BC	1.23 a	1.18 a	1.10 ab	1.17 A
B + C	1.18 ab	1.15 ab	1.07 b	1.14 C	1.26 a	1.18 a	1.05 b	1.16 A
Mean	1.20 A	1.18 A	1.18 A	1.23 A	1.19 B	1.13 C		

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

## 5. Fruit chemical properties:-

### 5.1. TSS (%)

It is evident from the data in (Table 6) that application of the reflective particle film kaolin, potassium silicate and calcium carbonate and their combinations increased TSS percentage. Second spraying date gave highest significant TSS values in both seasons (12.5 & 11.9). The interaction between spraying treatments and spraying dates induced high positive effect and surpassed all treatment (12.9 and 12.4 %), respectively in both seasons on the Anna apple fruits TSS% (potassium silicate + calcium carbonate treatment with second spraying date (first June)).

### 5.2. Acidity (%)

Table, 6 indicates that, lowest fruit acidity was achieved by control treatment compared to all reflective treatments (0.73 & 0.73) in both seasons. Concerning spraying dates, lowest acidity percentages were found with first and third dates. The interaction between the two studied factors showed that control treatment with all spraying dates gave lowest acidity percentages in both seasons.

### 5.3. Marketable fruit (%)

Table, 6 mentioned that marketable fruit percentage was increased significantly by all reflective particles film spraying with three spraying date compared to control in both studied seasons. However,

potassium silicate + calcium carbonate treatment surpassed other treatments and were gave the highest values of marketable Anna apple fruit (90.5 and 91.8 %), respectively in two seasons as compared with other treatments. Likewise, first June (the second spraying date) were surpassed other spraying dates and recorded high values of marketable Anna apple fruit (89.4 and 90.8 %), respectively in two seasons compared to other treatments. Generally, interaction between potassium silicate + calcium carbonate and spraying treatment in first June (second spraying date) was the most effective treatment and resulted in the highest significant percentages on the marketable Anna apple fruit (91.6 and 93.1 %), respectively in two studied seasons. Meanwhile, trees untreated recorded the lowest marketable Anna apple fruit during two seasons of studied.

**Table 6:** Effect of some reflective particles spraying; spraying dates and their interaction on fruit TSS%, total acidity % and marketable fruit (%) of Anna apple trees during 2018 and 2019 seasons.

Treatment	1 <sup>st</sup> Season				2 <sup>nd</sup> Season			
	1/5	1/6	1/7	Mean	1/5	1/6	1/7	Mean
	<b>TSS (%)</b>							
Control	11.3 cd	11.5 cd	11.4 cd	11.4 B	10.5 c	11.6 a-c	10.4 c	10.8 C
Kaolin 6% (A)	11.4 cd	12.2 b	11.4 cd	11.7 AB	10.5 c	11.4 a-c	10.7 c	10.9 BC
K silicate 3% (B)	11.5 cd	12.7 ab	11.8 bc	12.0 A	10.6 c	11.6 a-c	10.6 c	10.9 BC
Ca carbonate 3% (c)	11.4 a	12.5 ab	11.6 c	11.8 AB	10.7 c	11.5 a-c	10.5 c	10.9 BC
A + B	11.9 bc	12.7 ab	11.3 cd	12.0 A	10.8 bc	12.4 a	10.8 bc	11.3 AB
A + C	11.7 bc	12.9 a	11.0 d	11.9 AB	10.5 c	12.2 ab	10.5 c	11.1 BC
B + C	12.0 b	12.9 a	11.4 cd	12.1 A	10.9 bc	12.4 a	11.6 ac	11.7 A
Mean	11.6 B	12.5 A	11.4 B		10.6 B	11.9 A	10.7 B	
	<b>Total acidity %</b>							
Control	0.69 cd	0.75 b-d	0.75 b-d	0.73 C	0.71 bc	0.77 a-c	0.70 bc	0.73 C
Kaolin 6% (A)	0.72 b-d	0.78 bc	0.74 b-d	0.75 BC	0.75 a-c	0.78 a-c	0.69 c	0.74 C
K silicate 3% (B)	0.72 c-d	0.82 bc	0.68 cd	0.74 BC	0.77 a-c	0.82 a-c	0.80 a-c	0.80 A
Ca carbonate 3% (c)	0.74 b-d	0.79 bc	0.63 cd	0.72 C	0.73 bc	0.81 a-c	0.80 a-c	0.78 AB
A + B	0.79 bc	0.85 b	0.68 cd	0.77 AB	0.71 bc	0.83 ab	0.79 a-c	0.78 AB
A + C	0.72 b-d	0.83 b	0.68 cd	0.74 BC	0.73 bc	0.74 bc	0.75 a-c	0.74 BC
B + C	0.75 b-d	0.94 a	0.73 cd	0.81 A	0.74 bc	0.87 a	0.77 a-c	0.79 A
Mean	0.73 B	0.82 A	0.70 C		0.74 B	0.80 A	0.76 B	
	<b>Marketable fruit (%)</b>							
Control	85.8 b	87.2 ab	87.4 ab	86.5 C	87.4 ab	85.3 b	87.6 ab	86.8 C
Kaolin 6% (A)	90.0 a	90.5 a	87.5 ab	89.3 AB	90.6 ab	90.5 ab	90.5 ab	90.5 AB
K silicate 3% (B)	86.8 ab	91.1 a	88.7 ab	88.8 AB	90.9 a	90.1 a	90.0 ab	90.3 A
Ca carbonate 3% (c)	90.7 a	88.6 ab	84.8 b	88.1 BC	89.8 ab	91.7 ab	87.2 ab	89.6 B
A + B	89.2 ab	88.9 ab	89.0 ab	89.0 AB	90.9 ab	92.7 a	87.1 ab	90.2 AB
A + C	88.5 ab	88.0 ab	88.8 ab	88.4 AC	90.8 ab	92.4 ab	90.6 ab	91.3 AB
B + C	89.1 ab	91.6 a	90.7 a	90.5 A	91.9 ab	93.1 ab	90.4 ab	91.8 AB
Mean	88.6 A	89.4 A	88.25 A		90.3 A	90.8 A	89.1 B	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

Reflective particles film (kaolin, potassium silicate and calcium carbonate) reduce fruit surface temperature by increasing the reflection of visible and ultraviolet Light Glenn, *et al.*, (2001). The effectiveness of Kaolin in reducing sunburn in most cultivars and regions may be more strongly ascribed to the reduction in harmful radiation reaching the fruit surface than to the reductions in surface temperature, although the latter would lower the threshold for radiation damage. The same results were found by Gindaba and Wand, (2005) on apple. Kaolin clay particle film produced labeled reduced in sunburn percentages. The same trend was reported by Melgarejo, *et al.*, (2004) on pomegranate fruits.

The above results are in a harmony with that of apple Glenn *et al.* (2001) found that in both cases fruit set and final fruit number were highest when particle film application was initiated early in the season suggesting that photosynthesis was also increased early in the growing season and decreased fruit abortion. Also, the same author suggested that kaolin application increased the carrying capacity of apple trees in five of the six studies not only increasing fruit set but also increasing sizing the remaining fruit to a size equivalent to or larger than the reduced crop load on the conventional treatment, or increasing the size of fruit on trees with limited crop load. In addition, the essential roles of potassium silicate (silicon) on promotion growth and fruiting of Anna apple tree might be attributed to the effect of Si in enhancing the tolerance of the trees to all stresses, uptake and transport of water and different

nutrients, root development and antioxidant defense systems Gad El- Kareem *et al.*, (2014) and Hattori *et al.*, (2005).

### Conclusion

The results concluded that the application of kaolin at 6% , potassium silicate at 3% and calcium carbonate at 3% three times started in 1/5 (first May) 1/6 (first June) and 1/7 (first July) of Anna apple trees during the growing season, increased vegetative growth parameterize. (Leaf area and leaf total chlorophyll), fruit physical properties, i.e. (fruit length, fruit diameter, fruit volume and fruit shape index) and fruit chemical properties, i.e. (TSS, marketable fruit and decreased total acidity %). All kaolin, potassium silicate and calcium carbonate treatments enhancement Anna apple growth, productivity and fruit quality as compared to the control. On the other hand, all treated trees by potassium silicate + calcium carbonate treatment surpassed other treatments and were gave the highest values of all recorded parameters of Anna apple fruit as compared with other treatments in two seasons. Moreover, first June (the second spraying date) were surpassed other spraying dates and recorded high values of all recorded parameters of Anna apple in two seasons compared to other treatments. Generally, interaction between K si + CaCo<sub>3</sub> and spraying treatment in first June (second spraying date) was the most effective treatment and resulted in the highest significant percentages on the all recorded parameters of Anna apple fruit in two studied seasons. Meanwhile, trees untreated recorded the lowest Anna apple fruit parameters during two seasons of studied.

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