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Effect of Kaolin and Calcium Carbonate on Flowering initiation and fruit set of Kalamata and Manzanillo Olive Trees

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ABSTRACT

This work was carried out through 2015 and 2016 seasons on two olive cultivars (Kalamata and Manzanillo). Trees were 15 years old, grown in sandy Soil and planted at 5 X 5 meters apart under drip irrigation system. This investigation aimed to flowering parameters and fruit set of the two olive cultivars. Trees sprayed with concentration of Kaolin and Calcium Carbonate at (3, 5 and 7%) in three different dates (mid October, November and December). Results proved that spraying with $Al_2Si_2O_5(OH)_4$ 7% and $CaCo_3$ 7% treatments gave the highest number of inflorescences per shoot, number of flowers per inflorescence and sex ratio with good fruit set on mid-December in Kalamata cv. While, Manzanillo cv. gave with the same concentrations on mid-November a good initial and final fruit set with lowest fruit drop percentage.

Keywords: Olive (*Olea europea*), Kalamata, Manzanillo, Kaolin, Calcium Carbonate, Flowering parameters and Fruit set.

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). Climate change alters both average and extreme temperatures and precipitation patterns, which in turn influence crop yields, pest and weed ranges and introduction and the length of the growing season (Anonimus., 2008). Temperatures are often higher than optimal in ornamental production systems. This situation may stress plants, causing a reduction of quality and/or yield of ornamental crops (Restrepo-Díaz*et al.,* 2010).

Olive (*Olea europaea* L.) is an evergreen tree belongs to family Oleaceae, one of the oldest cultivated trees in the history of the world about 8000 years ago. It is a widely distributed tree grown in many arid zones of the world, native to all the countries around the Mediterranean region. The olive species includes many cultivars, which are used for oil extraction, or table olives and double purpose. Olive cultivation plays an important role in the economy of many countries; comparatively it resists drought and salinity conditions largely. In addition, it increases the land values where the soil is unsuitable for other crops (Hegazi *et al*., 2007).

In Egypt, table olive cultivars play an important role in economics of the growers and countries where most of the olive production is consumed as pickling products. Thereby, poor fruit set, high fruit shedding and consequently poor yields are considered critical factors for growing table cultivars.

Reflective materials can be applied as a leaf or fruit particle film coating to reduce solar heat stress, especially in areas with hot or sunny weather for a substantial part of the year. Such coatings can reduce heat stress, the extent of solar-injured fruit and water stress, and are involved in pest control and the suppression of disease incidence (Glenn and Puterka, 2005). Some of the reflective materials that may be used as leaf coating material include kaolin and calcium carbonate.

Kaolin has been tested in different horticultural crops and its response has been heterogeneous (Rosati *et al.* 2006). Kaolin showed a reduction on leaf temperature in apple trees (Wunsche *et al.,* 2004), and improved light-saturated CO2 assimilation rate (Amax) and stomatal conductance (gs) in citrus at midday (Jifon and Syvertsen 2003). However, kaolin has no effect on gas exchange parameters in pepper (Russo and Diaz-Perez 2005) and did not suffice to mitigate the adverse effects of heat and water stress on photo- synthesis in almond and walnut (Rosati *et al.* 2006), and enhanced water loss from fruit in tomato (Nakano and Uehara 1996).

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Calcium carbonate ($CaCO_3$) is a white, nontoxic, odorless solid. It is one of the most common and widely dispersed minerals occurring in eggshells, limestone, marble, seashells and other bio minerals (McGregor, 1963). Because of its harmlessness and low cost, calcium carbonate has been used for a variety of purposes such as a neutralizing agent, filler, flux and in cement (McGregor, 1963; Sheikholeslami and Ong, 2003).

Researchers have studied the effects of these reflective clay particle films on plant physiology processes. For example, kaolin particle film is associated with increased water use efficiency in citrus under excessive heat stresses (Jifon and Syvertsen, 2003). In addition, kaolin treatment increased fruit weight and redness of 'Empire' apples (Glenn *et al.,* 2002, 2003). Although calcium carbonate has none of the positive effects of kaolin particle film, it reflected more photo synthetically active radiation (PAR) than kaolin (Glenn *et al*., 2003).

The objectives of this experiment were to study the light transmission of two coating calcium carbonate and kaolin clays for developing flowering parameters in Olives.

Materials and Methods

This study was carried out during two successive seasons, (2015 and 2016) in a private orchard located at Ismailia governorate, Egypt. The study was conducted on 15 years old olive trees of Kalamata and Manzanillo cvs., planted at 5 X 5 m apart grown in sandy soil, under drip irrigation system and uniform in shape and received the common horticultural practices. The orchard soil analysis are given in (Table 1) and water irrigation analysis are given in (Table 2) according to procedures which are outlined by (Wild *et al.,* 1985).

Table 1: Some physical and chemical analysis of the orchard soil:

Parameters	Depth of simple (cm)		
	Surface sample	30 cm depth	60 cm depth
pH	8.02	8.70	8.11
EC(dSm-1)	3.80	0.80	1.70
	Soluble cations (meq\l)		
Ca^{++}	6.00	2.50	3.00
Mg^{++}	4.00	1.50	1.50
Na^{+}	28.60	4.40	12.90
K^{+}	0.12	0.14	0.78
	Soluble anions (meq\l)		
$CO3^{-}$	-	-	-
$HCO3^{-}$	4.40	2.40	2.00
Cl^{-}	27.20	5.00	13.00
$SO4^{=}$	7.12	1.14	3.18

Table 2: Chemical characteristics of water weal used for the present study:

Parameters	values
pH	7.49
EC(dSm^{-1})	4.40
Soluble cations (meq\l)	
Ca^{++}	7.50
Mg^{++}	5.00
Na^{+}	33.1
K^{+}	0.16
Soluble anions (meq\l)	
$CO3^{=}$	-
$HCO3^{-}$	1.60
Cl^{-}	40.00
$SO4^{=}$	4.16

Experimental design

The treatments will be arranged in a randomized complete block design (RCBD), the experiment contains seven treatments, each contains three replicates and the replicate represented by one tree. The normal horticulture practices that used in the farm were applied to all Kalamata and Manzanillo olive trees.

Experimental material

Kaolin is a clay mineral, part of the group of industrial minerals, with the chemical composition $Al_2Si_2O_5(OH)_4$. It is a layered silicate mineral, with one tetrahedral sheet of silica (SiO_4) linked through oxygen atoms to one octahedral sheet of alumina (AlO_6) octahedral. Rocks that are rich in kaolin are known as kaolin or china clay.
Calcium carbonate is a chemical compound with the formula $CaCO_3$. It is a common substance found in rocks as the minerals calcite and aragonite (most notably as limestone, which is a type of sedimentary rock build mainly of calcite).

Treatments:

Effect of spraying with two different Kaolin and Calcium Carbonate, this experiment included seven treatments as follows:

T0 Control.
T1 $Al_2Si_2O_5(OH)_4$ (3%)
T2 $Al_2Si_2O_5(OH)_4$ (5%)
T3 $Al_2Si_2O_5(OH)_4$ (7%)
T4 $CaCo_3$ (3%).
T5 $CaCo_3$ (5%)
T6 $CaCo_3$ (7%)

All treatments were appliedon three different dates. The mid of October, November and December.

Measurements

1. Number of inflorescences per shoot: the labeled twenty shoots was calculated.
2. Number of total flowers per inflorescence: Sample of 20 inflorescences was taken from every tree and total number of flowers per inflorescences was counted.
3. Sex ratio: The percentage of perfect flowers to total flowers was calculated for every replicate.
4. Fruit set and fruit drop: fruit set percentage as number of fruits / shoot at two times first after 20 days from full bloom as initial fruit set and the second 60 days after full bloom as final fruit set according to Fernandez and Gomez, (1985). Initial fruit set, final fruit set & fruit drop percentages were estimated as follows:

Initial fruit set (%) = [Number of fruit set (20 days after full bloom) / shoot length (cm)] × 100.
Final fruit set (%) = [Number of fruit set (60 days after full bloom) / shoot length (cm)] × 100.
Fruit drop (%) = [(Initial fruit set - Final fruit set) / Initial fruit set] × 100.

Statistical analysis

All obtained data during both 2015 and 2016 experimental seasons were subjected to analysis of variances (ANOVA) according to Snedecor and Cochran, (1980) using MSTAT program. Least significant ranges (LSR) were used to compare between means of treatments according to Duncan, (1955) at probability of 5 %.

Results and Discussion

No. inflorescences/shoot:

Comparison between the treatments means for the number of inflorescences per shoot (Table 3) indicated that spraying with $CaCo_3$ at 7% and $Al_2Si_2O_5(OH)_4$7% treatments gave the highest number of inflorescences per shoot in Kalamata (16.39 & 12.83) and Manzanillo (15.56 and12.67) Cultivars in the both seasons, respectively with insignificant differences between the other treatments across all studied application dates. On the other hand, the differences between the three studied dates of application were insignificant across all studied treatments in Kalamata cv. and gave the maximum number of inflorescences per shoot (13.54 and 11.00) in Manzanillo cv. in both seasons, respectively. The interaction between treatments and application dates was significant. The variation ranged from 11.00 to 17.25 and from 10.56 to 17.92 in the first season, between 11.67 to 13.50, and between 8.00 to 14.92 in the second season in Kalamata and Manzanillo Cultivars, respectively.

No . flowers / inflorescence:

The number of flowers per inflorescences per shoot indicated in (Table 3) spraying with $CaCo_3$ at 7% concentration treatment gave the highest number of flowers per inflorescence (23.28 and 11.61) in Kalamata cv. and (27.89 and14.44) in Manzanillo cv. in both season, respectively. On the other hand, the differences between the three studied dates of application were insignificant across all studied treatments in Kalamata cv. but in the second date gave the maximum number of flowers per inflorescence (25.65 and 13.18) in Manzanillo cv. The interaction between treatments and application dates was significant. The variation ranged from 18.33 to 24.50 and from 18.00 to 30.00 in the first season, between 6.33 to 12.50, and between 8.00 to 17.00 in the second season in Kalamata and Manzanillo Cultivars, respectively.

Initial and final fruit set (%):

As shown in Table (4) percentage of initial and final fruit set were significantly affected by the different treatments in two seasons of studied. The highest initial fruit set was found under treatment $CaCo_3$ 7% in Kalamata cv. (45.73 & 39.65%) and (46.29 and 39.99%) in Manzanillo cv. during the first and second seasons, respectively, compared with other treatments. On the other hand, the application of treatments in the third date gave the maximum number of initial fruit set (37.9% and 40.47%) in the first season in both Kalamata and Manzanillo cultivars, respectively. Meanwhile in the second season, the second date gave the highest vales (35.06% and 36.33%) in the same cultivars. The interaction between treatments and application dates was significant. The variation ranged from 25.41 to 48.11% and from 28.91 to 65.86% in the first season and between 24.09 to 43.56% and between 16.83 to 56.78% in the second season in the both Kalamata and Manzanillo cultivars, respectively. Other treatments were intermediate. Concerning final fruit set data presented in the same table reveled that final fruit set was the same trend of initial fruit set through studied seasons.

Sex ratio:

Kalamata Cultivar

Sex expression as percentage of perfect flowers to total flowers are presented in Fig (1). Studying the effect of different treatments on sex expression it appeared that, $Al_2Si_2O_5(OH)_4$ 7% in mid-December was the most effective treatment and resulted in the highest significant percentages during the first season. Meanwhile in the second $CaCo_3$ 7% in mid November and December recorded the highest values. On the other hand, trees without treatment recorded the lowest sex expression during the both season. Other treatments were intermediate.

Manzanillo Cultivar

Sex expression are presented in Fig (2). Studying the effect of different treatments on sex expression, it appeared that, $CaCo_3$ 7% in mid December was the most effective treatment and resulted in the highest significant percentages. On the other hand, $Al_2Si_2O_5(OH)_4$ 3% in mid December recorded the lowest sex expression during the first. Meanwhile in the second $Al_2Si_2O_5(OH)_4$ 3% in mid October recorded the lowest values. Other treatments were intermediate.

Table 3: Effect of Kaolin and Calcium Carbonate Spraying on No. inflorescences / shoot and No. flowers / inflorescence of Kalamata and Manzanillo Olive Cultivars in 2015 and 2016 seasons.

Treatments	No. inflorescences/shoot								No. flowers / inflorescence							
	Kalamata Cultivar				Manzanillo Cultivar				Kalamata Cultivar				Manzanillo Cultivar			
	Oct.	Nov.	Dec.	Mean	Oct.	Nov.	Dec.	Mean	Oct.	Nov.	Dec.	Mean	Oct.	Nov.	Dec.	Mean
Season 2015																
Control	11.00i	11.00i	11.00i	**11.00I**	10.56 i	10.56 i	10.56 i	**10.56 I**	18.33f	18.33f	18.33f	18.33F	20.57 hi	20.57 hi	20.57 hi	**20.57 D**
$Al_2Si_2O_5(OH)_4$3%	14.67efg	14.00fgh	15.00def	**14.56C**	12.33f-i	16.00 ab	14.00cde	**14.11 B**	21.67de	21.33e	22.00cde	21.67C	26.67cde	28.33abc	19.33 ij	**24.78 B**
$Al_2Si_2O_5(OH)_4$5%	16.33abc	13.17h	14.33efg	**14.61C**	11.00ghi	13.07def	12.50fgh	**12.19 C**	23.33ac	21.17e	21.67de	22.06BC	25.00efg	27.00bcd	18.00 j	**23.33 C**
$Al_2Si_2O_5(OH)_4$7%	14.33efg	16.83a	16.17abc	**15.78AB**	17.92 a	15.00bcd	13.75cde	**15.56 A**	21.00e	24.33a	23.17bd	**22.83AB**	25.33def	26.00def	25.33def	**25.55 B**
$CaCo_3$ 3%	14.50efg	15.50bcd	13.67gh	**14.56C**	14.50bcd	12.67efg	12.92efg	**13.36 B**	21.50e	21.83de	20.67e	**21.33C**	24.00 g	27.33bcd	25.33def	**25.56 B**
$CaCo_3$5%	14.75efg	16.50ab	14.75efg	**15.33BC**	12.67efg	13.67cde	15.08 bc	**13.81 B**	21.75de	23.50ab	21.42e	**22.22ABC**	21.67 h	20.33 hi	25.00efg	**22.33 C**
$CaCo_3$7%	15.08cde	17.25a	16.83a	**16.39 A**	15.00bcd	10.67 hi	16.00 ab	**13.89 B**	22.08cde	23.25bcd	24.50a	**23.28 A**	24.67 fg	30.00 a	29.00 ab	**27.89 A**
Mean	**14.38 A**	**14.89 A**	**14.54 A**		**13.43 A**	**13.09A**	**13.54 A**		**21.38 A**	**21.96 A**	**21.68 A**		**23.99 B**	**25.65 A**	**23.22 B**	
Season 2016																
Control	9.00j	9.00j	9.00j	9.00G	7.56 f	7.56 f	7.56 f	7.56 F	6.33d	6.33d	6.33d	6.33D	8.57 gh	8.57 gh	8.57 gh	8.57 GH
$Al_2Si_2O_5(OH)_4$3%	11.67f	12.00de	12.00de	11.89BC	9.83 e	13.00 b	12.83 b	11.89 B	9.67bc	9.67bc	10.00bc	9.78C	15.33 ab	15.00abc	13.00bcd	14.44 A
$Al_2Si_2O_5(OH)_4$5%	13.00bc	10.17i	11.33g	11.50C	8.00 f	11.07 cd	9.83 e	9.64 D	11.33bc	8.83c	10.00bc	10.06BC	13.00bcd	14.33abc	9.33 gh	12.22 BC
$Al_2Si_2O_5(OH)_4$7%	11.33g	13.17b	13.50a	12.67AB	14.92a	12.00 bc	11.08 cd	12.67 A	9.00c	12.33a	11.17ab	10.83AB	13.67bcd	17.00 a	11.33d-g	14.00 AB
$CaCo_3$ 3%	11.50fg	12.17d	10.67h	11.44C	12.50 b	10.00 de	10.58 de	11.03 C	9.50bc	9.83bc	8.67c	9.33C	11.00efg	15.33 ab	13.67bcd	13.33AB
$CaCo_3$5%	11.75ef	13.50a	10.75h	12.00BC	10.50 de	10.67de	12.08 bc	11.08 C	9.75bc	11.17ab	9.92bc	10.28BC	10.50fgh	8.00 h	12.67bcd	10.39CD
$CaCo_3$7%	12.75c	12.25d	13.50a	12.83 A	12.00 bc	7.67 f	13.00 b	10.89 C	10.08bc	12.25a	12.50a	11.61 A	12.33cde	14.00bcd	17.00 a	14.44 A
Mean	**11.57 A**	**11.75 A**	**11.54 A**		**10.76AB**	**10.28 B**	**11.00 A**		**9.38 A**	**10.06 A**	**9.80 A**		**12.06 A**	**13.18 A**	**12.22 A**	

Table 4: Effect of Kaolin and Calcium Carbonate Spraying on Initial fruit set(%)and Final fruit set (%) of Kalamata and Manzanillo Olive Cultivars in 2015 and 2016 seasons.

Treatments	Initial fruit set (%)								Final fruit set (%)							
	Kalamata Cultivar				Manzanillo Cultivar				Kalamata Cultivar				Manzanillo Cultivar			
	Oct.	Nov.	Dec.	Mean	Oct.	Nov.	Dec.	Mean	Oct.	Nov.	Dec.	Mean	Oct.	Nov.	Dec.	Mean
Season 2015																
Control	23.63h	23.63h	23.63h	23.63D	28.91 j	28.91 j	28.91 j	**28.91 D**	16.40j	16.40j	16.40j	16.40 E	17.95 ij	17.95 ij	17.95 ij	**17.95 E**
$Al_2Si_2O_5(OH)_4$3%	32.68fg	35.87efg	41.02bcd	36.52B	31.64hi	35.49fg	34.35 g	**33.83 C**	23.08gh	25.07fgh	31.33bcd	26.49C	22.05 gh	24.68 fg	25.91 ef	**24.21 C**
$Al_2Si_2O_5(OH)_4$5%	44.52bc	32.57fg	37.14def	38.08B	37.84ef	25.68 k	37.22ef	**33.58 C**	35.44abc	22.89gh	26.56fgh	28.29C	26.89 ef	13.55 k	25.43 f	**21.96 D**
$Al_2Si_2O_5(OH)_4$7%	38.64de	45.23ab	44.17bc	42.68 A	30.93 ij	42.20 d	44.34cd	**39.16 B**	28.20efg	35.10abc	34.20abc	32.50B	16.55 jk	26.83 ef	26.89 def	**23.42 CD**
$CaCo_3$ 3%	38.74de	25.41h	31.68g	31.94C	53.39 b	45.98 c	38.52 e	**45.97 A**	27.71efg	15.86j	22.03hi	21.87D	33.03b	25.70ef	22.19 gh	**26.97 B**
$CaCo_3$5%	36.56def	38.11de	39.60cde	38.09B	39.16 e	43.52cd	34.10gh	**38.93 B**	27.05efg	27.89efg	28.44def	27.79C	29.90cd	20.13hi	28.51cde	**26.18 B**
$CaCo_3$7%	41.06bcd	48.11a	48.03a	**45.73 A**	33.76gh	39.24 e	65.86 a	**46.29 A**	31.08bcd	38.08ab	38.39a	35.85 A	30.11bc	18.79 j	47.68 a	**32.19 A**
Mean	**36.55AB**	**35.56B**	**37.90 A**		**36.52 B**	**37.29 B**	**40.47 A**		**26.99AB**	**25.90B**	**28.19 A**		**25.21 B**	**21.09 C**	**27.79 A**	
Season 2016																
Control	35.83def	35.83def	35.83def	**35.83 B**	27.27fh	27.27fh	27.27fh	**27.27 D**	23.52de	23.52de	23.52de	**23.52 C**	14.01gh	14.01gh	14.01gh	**14.01E**
$Al_2Si_2O_5(OH)_4$3%	37.67b-e	25.30i	32.11fg	**31.69CD**	30.38 ef	33.52de	37.02cd	**33.64BC**	22.38e	16.47h	22.75e	**20.53D**	20.95 f	24.07 e	23.81 ef	**22.95 C**
$Al_2Si_2O_5(OH)_4$5%	34.75efg	27.33hi	27.07hi	**29.72D**	35.87cd	16.83 j	33.61de	**28.77 D**	27.67c	17.58gh	20.45efg	**21.90D**	23.24ef	7.71 i	24.27 e	**18.41 D**
$Al_2Si_2O_5(OH)_4$7%	31.52gh	40.38abc	38.98bcd	**36.96B**	21.73 i	36.05cd	36.67cd	**31.48 C**	23.00e	33.92ab	32.35b	**29.76 A**	13.06 h	27.68 d	25.57 de	**22.10 C**
$CaCo_3$ 3%	27.85hi	36.36cde	26.52i	**30.24CD**	29.40 fg	24.92 hi	28.07 fgh	**27.47 D**	18.45gh	26.78c	17.45gh	**20.90D**	26.21de	16.39 g	15.44 gh	**19.35 D**
$CaCo_3$5%	31.89gh	41.56ab	24.09i	**32.51C**	45.45 b	25.83 gh	34.86 cd	**35.38 B**	23.38de	34.51ab	15.42h	**24.44B**	34.92 b	16.39 g	25.14 de	**25.49 B**
$CaCo_3$7%	36.74cde	38.65bcd	43.56a	**39.65 A**	37.48 c	25.71 gh	56.78 a	**39.99 A**	26.42cd	21.27ef	36.22a	**27.97 A**	31.05 c	12.62 h	48.80 a	**30.82 A**
Mean	**33.75AB**	**35.06 A**	**32.59B**		**32.51 B**	**27.16C**	**36.33 A**		**23.55 A**	**24.86 A**	**24.02 A**		**23.35 B**	**16.98 C**	**25.29 A**	

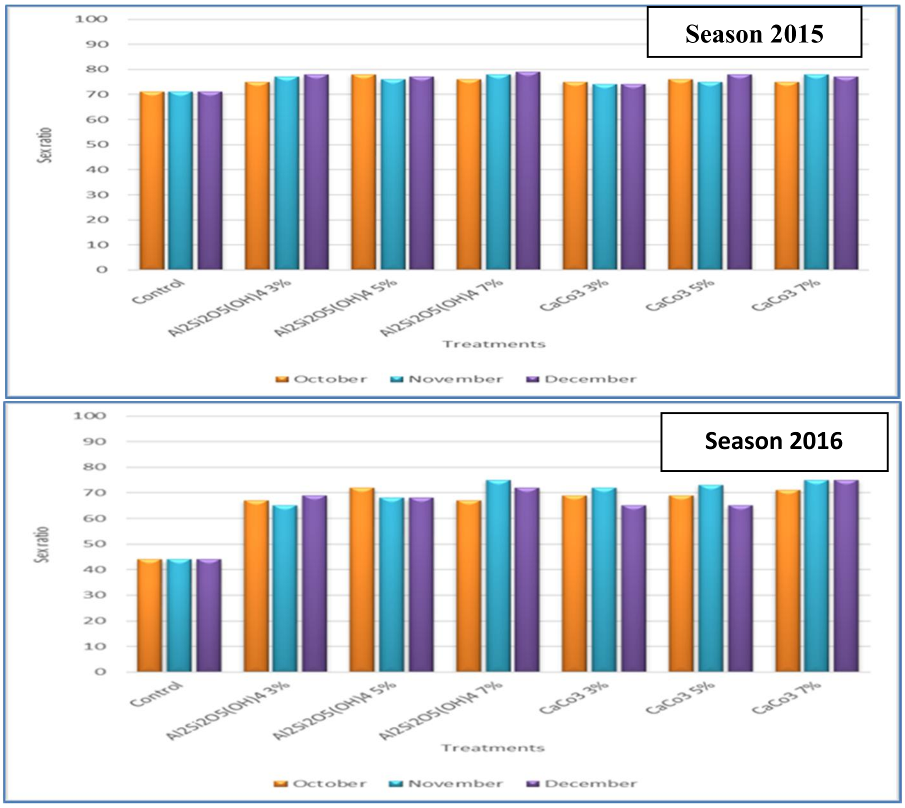

Fig. 1: Effect of Kaolin and Calcium Carbonate Spraying on sex ratio (%) of "Kalamata "olive trees in 2015 and 2016 seasons.

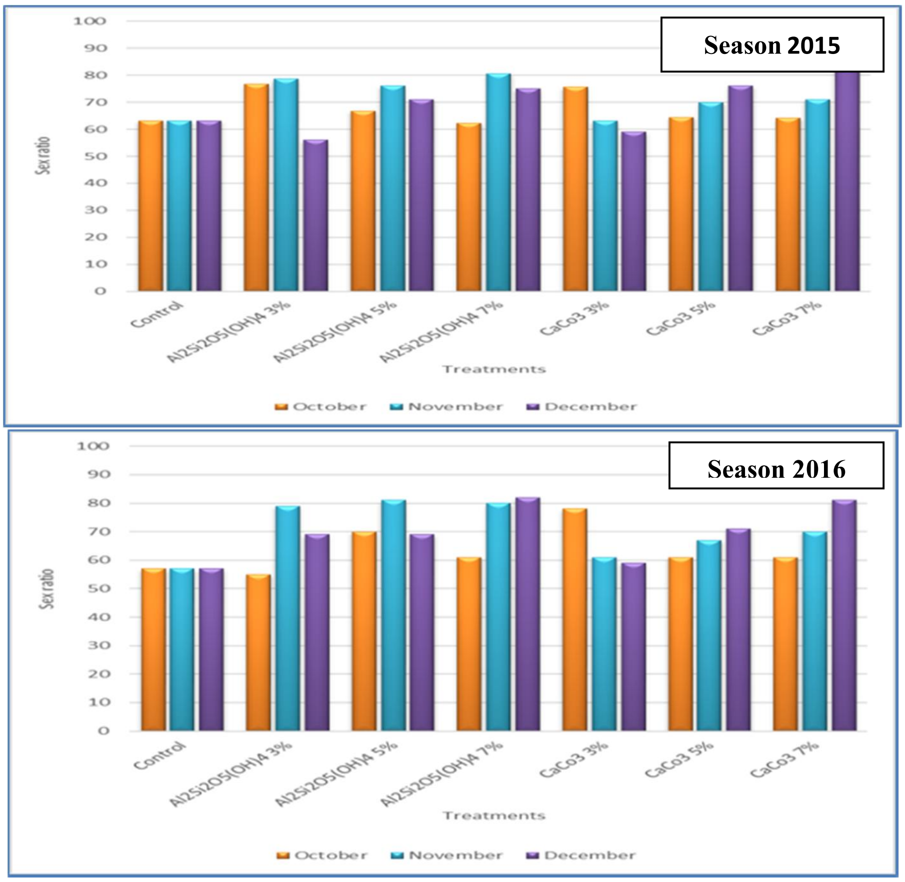

Fig. 2: Effect of Kaolin and Calcium Carbonate Spraying on sex ratio (%) of "Manzanillo "olive trees in 2015 and 2016 seasons

Fruit drop%:

Kalamata Cultivar

Data in Fig (3 and 4) showed that, there was no clear trend concerning different treatments on fruit drop. The highest fruit drop percentage was found under $CaCo_3$ 3% and CaCo3 5% for mid-November treatment in the first season in the two Kalamata and Manzanillo cultivars, respectively. Meanwhile in the second $CaCo_3$ 7% and $Al_2Si_2O_5(OH)_4$ 5% for mid-November recorded the highest values. On the contrary, the lowest values were recorded with $CaCo_3$ 7% for mid-December and mid-October for the two cultivars Kalamata and Manzanillo cultivars, respectively in the first season except CaCo3 3% for mid-October in Manzanillo cv. in the second season.

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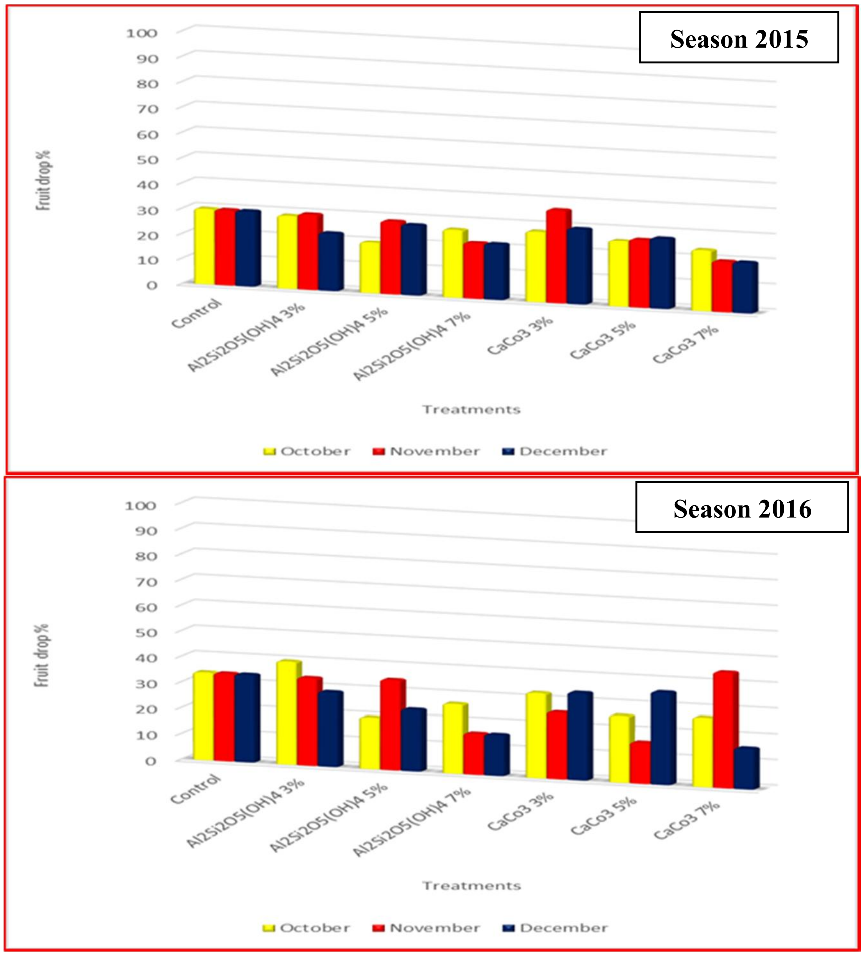
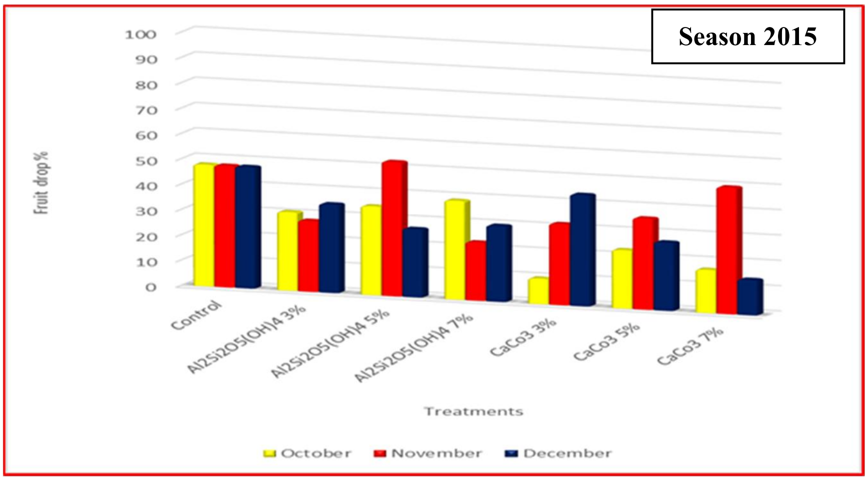


Fig. 3: Effect of Kaolin and Calcium Carbonate Spraying on fruit drop (%) of "Kalamata "olive trees in 2015 and 2016 seasons.

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 medfly infestations‹ reduction fruit disorders and weight.

Similar results are found in Olive (Saour and Makee,) showed that fruit infestation levels were significantly reduced on kaolin-treated trees compared with untreated trees. Kaolin particle film successfully suppressed B. oleae populations and provided season-long insect control (>14 weeks) whereas the insecticide dimethoate failed to protect olives for as long a period after the last spray. Consistent with previous findings, the M-99-099 kaolin particle film proved to be a promising alternative method to synthetic insecticides and could be used to control B. oleae in olive



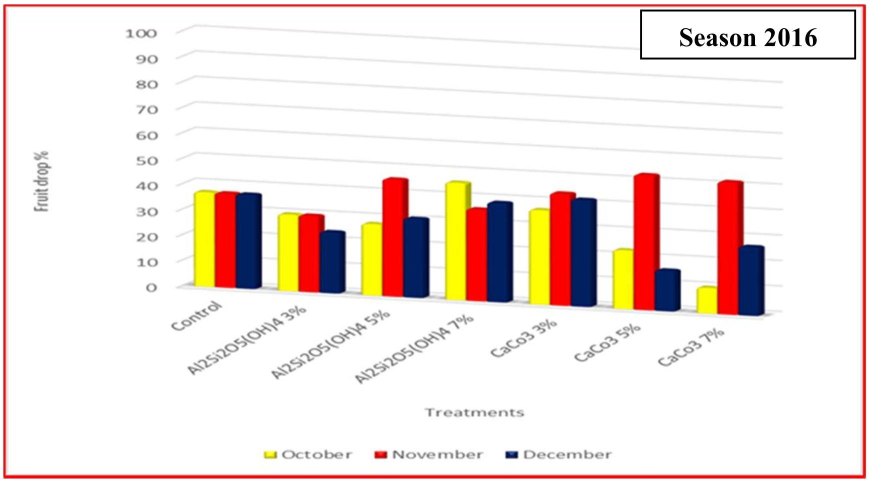


Fig. 4: Effect of Kaolin and Calcium Carbonate Spraying on fruit drop (%) of "Manzanillo "olive trees in 2015 and 2016 seasons

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