Effect of some Biological Stimulants and Kaolin Particles Sprays on Fruit Retention, Productivity and Fruit Quality of Washington Navel Orange Trees

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Abstract: This investigation was performed out during seasons 2016 and 2017 at private grove in El-Salhia El-Gadida, Sharkia Governorate, Egypt on 11 year-old Washington navel orange trees are growing in sandy soil under drip irrigation system. The effects of spraying salicylic acid (SA) (200 and 400 mg/L), Jasmine oil (JO) (2 and 4 ml/L), radish root extract (RRE) (50 and 100 ml/L) and Kaolin particles film (KPF) (5000 and 10000 mg/L) were studied on vegetative growth (leaf area index and leaf chlorophyll value), fruit set, fruit retention, productivity (yield as number and weight per tree), fruit quality parameters (fruit weight, fruit diameter, secondary fruit diameter, peel thickness, firmness, juice content, TSS, TA, TSS/TA ratio, ascorbic acid) and nutritional status (N, P, K and Ca contents). The current study clearly demonstrated that SA at all concentrations especially at 200 mg/L improved leaf area index, fruit retention, fruit number per tree, fruit yield, fruit firmness, juice content percentage, TSS, ascorbic acid and decreased the total acidity in orange juice, as well as increased nutritional status (N and P),. Also, a positive response in fruit retention, fruit weight, peel thickness, leaf area, chlorophyll value and N and P contents by foliar application of KPF at all concentrations under study. Moreover, Foliar sprays with JO at 2 ml/l and RRE at 100 ml/l significantly increased fruit set, fruit weight, fruit diameter, peel thickness, and lowered acidity percentage and increased Ca content.

Keywords: Navel orange, salicylic acid, Jasmine oil, Jasmonic acid, radish root extract, kaolin, fruit quality

INTRODUCTION

Orange occupies the first rank among all fruits cultivated in Egypt, with about more than four million metric tons produced in 2015 (El-Boray *et al.,* 2015), and Egypt exports of orange exceeded 1.6 million tons in 2016/2017 (USDA 2016, 2017 and 2018). Navel orange is the most important citrus fruit in Egypt. The flowers, fruitlets and fruit quality are sensitive to adverse climatic and soil conditions. Thus, yield of Washington navel orange trees growing in sandy soil conditions are usually reduced by sever shedding of flowers and fruitlets and lower fruit quality. Efforts should be exerted constantly to increase cultivated area, production, and improve fruit quality of Navel orange in order to satisfy local consumption and increasing demands on Egyptian oranges in international markets.

Biological stimulants such as salicylic acid, Jasmine oil and radish root extract in addition to kaolin particles show some effects on both vegetative growth and production of fruit trees (Kittikorn and Kanlayanarat, 2004; Schaller and Stintzi, 2009; Zarins *et al.*, 2009; Glenn and Puterka, 2010; Sabry *et al.*, 2011; Schlink, 2011; El-Zayat *et al.*, 2017).

Salicylic acid (SA) is a natural phenolic compound that plays a vital role in mitigating biotic and abiotic stresses in plants. Foliar spraying of salicylic acid is effective in controlling tree growth and increase productivity when applied on orange and Kinnow mandarin trees (Ashraf *et al.*, 2013; El-Gioushy, 2016).

Jasmine oil (JO) or Jasmonate as a plant substance may play a role in plant development under various physiological biotic and abiotic stresses (Vick, 1984; Schlink 2011; Ismail *et al.*, 2012). JO effects related genes which have illustrated a substantial role in enhancing fruit yield and quality in many plants under different conditions (Ahmed *et al.*, 2016). Jasmonic acid treatment in lower concentrations on grapevines encouraged flowering, improved percentage of bud burst and good yield with high bunch quality (Sanders *et al.,* 2000; Piotrowska *et al.,* 2009) and on date palm according to Zaki *et al*. (2017).

Radish is an important Genus in Brassicaceae family as well as It is a source of medicinally important substances isothiocyanates and peroxidases (Curtis, 2003). Radish roots (*Raphanus sativus*) extracts (RRE) have very useful components which have cysteine as antimicrobial substance used on tomatoes, cucumbers, peppers (Zarins *et al.*, 2009). In addition, Root extract illustrated higher antifungal activity under various concentrations where reduced fungal biomass on plants (Javaid and Bashir, 2018).

Kaolin particle film (KPF) is a natural mineral extracted in Egypt and from other countries used mainly insect control, anti-sunburn agent and has some physiological effects of drought and heat stress on crops. In addition, repelling grasshoppers, leaf rollers, mites, thrips and some moth varieties, psylla, flea beetles (Rosati, 2007; Braham *et al.,* 2007; Skewes, M. 2014). Kaolin treatment at different concentrations increased fruit firmness of navel orange (Ali and Elhamahmy, 2015) and protected of sunburn for Balady mandarin (Ennab *et al.,* 2017) and apple fruits (Glenn and Puterka, 2010).

Hence, this research work was undertaken to investigate the effect of salicylic acid, Jasmine oil, radish root extract as a biological stimulants and kaolin particles as a natural mineral under fruit against trees factors (temperature and lack of irrigation) on vegetative growth, fruit set, fruit retention, productivity and fruit quality of Washington navel orange.

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MATERIALS AND METHODS

This work was conducted during two successive seasons 2016 and 2017 on 11-year-old trees of Washington navel orange (*Citrus sinensis* L. Osbeck) budded on sour orange. The trees grown in sandy soil under drip irrigation system at a private grove, El-Salhia El-Gadida, Sharkia Governorate, Egypt. Navel orange trees were planted at 5*5 meters apart and subjected the same annual horticultural management. The complete randomized block design was used, where the experiment involved 9 treatments, having four replicates with one tree in each. The treatments included the foliar applications of salicylic acid (SA) at 200 and 400 mg/L; Jasmine oil (JO) at 2 and 4 ml/L; Radish root extract (RRE) at 50 and 100 ml/L; Kaolin particle film (KPF) at 5000 and 10000 mg/L; control (the water treated trees). Treatments were applied five times to selected trees at full bloom stage and continuing periodically once every 15-day- intervals. A single spray with ≈5.0 liters of solution per tree in the morning of a day using handgun sprayer. Tween-80 at 0.03% as wetting agent was used with the applied solutions before spraying.

From the orchard soil, sample was taken at 50 cm depth to determine physico-chemical properties and stipulated in Table (1) (Nelson and Sommers, 1982; Jackson, 1962).

Table (1): Soil composition used in this study

Physical properties				Chemical properties			
				Cations	**meq/l**	**Anions**	**meq/l**
Soil texture	**Sand (%)**	**Loam (%)**	**Clay (%)**	Ca^{++}	3.0	Cl^{-}	8.0
Sandy	95.0	3.00	2.00	Mg^{++}	2.0	HCO_3	4.0
EC (ds/m)	**Soil pH**	**Organic matter (%)**		Na^{+}	8.0	CO_3	0.0
1.35	7.37	0.423		K^{+}	0.5	SO_4	1.5

Four branches of three years of age having similarities in vigour and size were chosen and labeled per tree in early spring of both seasons and the following parameters were studied.

Initial fruit set and retained fruit percentage:

Initial fruit set and fruit retention percentages were determined by counting the initial number of flowers at full bloom on the selected branches and number of fruitlets after 15 days from full bloom. Retained fruit on selected branches periodically calculated up to harvest according to Westwood (1978) and Khan *et al.* (2009) as follow:

$$\text{Fruit set (\%)} = \frac{\text{Total number of fruitlets}}{\text{Total number of flowers}} \times 100$$

$$\text{Fruit retention (\%)} = \frac{\text{Total number of retained fruit at subsequent dates}}{\text{Total number of fruitlets}} \times 100$$

Fruit yield: At harvest date, yield per tree was estimated by fruit number and fruit weight and expressed in kg.

Fruit quality: Samples of 15 fruits were randomly selected at harvest time from each tree to determine fruit dimensions, secondary fruit diameter navel diameter), and peel thickness by using digital vernier caliper and expressed as cm. Firmness (kg/cm^2) of peeled fruit of navel orange on the two opposite sides of each fruit was measured by using a hand Magness Taylor pressure tester, fitted with a 0.7 cm convex plunger.

Fruit Juice content **(%)** was extracted and calculated using the equation: (Juice fruit weight/fruit weight) x 100.

Total Soluble solids **(TSS %)** estimated by using Digital refractometer (LCII, Medline scientific, RS-95, United Kingdom) at room temperature.

Total acidity **(TA %):** Titratable acidity was determined in fruit juice as percentage of citric acid by titration against 0.1N of NaOH using phenolphthalein indicator (AOAC, 1995).

TSS/TA ratio was calculated by dividing the percentage of TSS on TA values.

Vitamin C value **(VC):** Ascorbic acid was estimated using titration with 2,6-dichlorophenolendophenl dye as mg/100 ml juice (AOAC, 1995).

Vegetative determinations:

Leaf Chlorophyll content: total chlorophyll contents were measured in 20 fresh leaves per tree (6th leave from the base on the shoot), using Minolta meter SPAD-502 (Benedict and Swidler, 1961; Peterson *et al.,* 1993).

Vegetative growth and nutrient contents: From the middle of non-fruiting shoots (6th leave from the base on the shoot), twenty five mature leaves of 5-6 months old, growing from spring growth flush, were randomly taken from each tree at the last week of July in both seasons to determine the following:

Leaf area index: it was measured using the Planimeter (No. 19723, JOPAT, Japan) and expressed as cm^2.

Leaf nutrient contents: Leaves were carefully cleaned, rinsed with distilled H_2O, dried at 70°C, ground, thinned and digested according to Chapman and Pratt (1961). Leaf content percentages of N, P, K, Ca and Na were determined using various methods (Karla, 1998; Wilde *et al.,* 1985).

Statistical Analysis:

Data obtained were statistically analyzed and significant differences between different treatments means were determined by using Least Significant Difference test (LSD at 0.05) according to Steel *et al.* (1997).

RESULTS AND DISCUSSION

Effect on fruit set and fruit retention:

Initial fruit set and retained fruit percentages are shown in Table (2). It is evident that all concentrations of SA, JO, RRE, and KPF significantly increased the percentage fruit set after 15 days from full bloom than the control in the two seasons. Both Radish root extracts at 100 mlL^{-1} and Jasmine oil at 4 mlL^{-1} gave the highest fruit set % after 15 days from full bloom (14.57 and 14.24) in the first season and (14.59 and 14.80) in the second season, respectively. Preceding results followed by SA treatment at 400mg/L and Jasmine oil at 2 mlL^{-1} where significantly increased fruit set % (14.64 and 14.52) in the second season compared to the control. On the other hand, KPE treatments improved slightly fruit set % by 12.18 and 14.13 compared to control (11.10 and 12.10, respectively) in two seasons. The final fruit setting is controlled by the capacity of the tree to supply metabolites to developing fruitlets during post anthesis, and by the climate and orchard management.

Concerning retained fruit (Table 2), all investigated treatments enhanced the percentage of fruit retention at certain intervals after full bloom in comparison with the control during 2016 and 2017 seasons. Thereafter, the percentages were sharply decreased within 02 July and 10 July during both seasons and remained nearly steady after that up to harvest. These lower percentages of fruit set during May and June months may be a result of severe competition between flowers and fruitlets for water, nutrition and unfavorable weather condition during this period. SA at 200 mg/l had the highest effect of increasing percent of fruit retained during different ages of fruit development compared with all of the other treatments in both seasons. Meanwhile, treatment with JO at 2 ml/l or KPF at 5000 mg/l and 10000 mg/l resulted in significantly highest percentages of retained fruit at most stages of fruit development in 2016 and 2017 seasons.

The obtained results was in line with mentioned by Ruiz *et al.* (2001) who cited that after 30 days of flower opening, fruitlets retention was around 13%, and consistent also with the results of Zaghloul and Moursi (2017) who cited that navel orange set reached about (6.3% - 7.8%) when counted at end of June (after about 60 days from full bloom). SA may be significantly decreased the accumulation of the gene transcripts of auxin-responsive, GH3-like protein and 12-oxo-PDA reductase, but resulted in higher percentages of young fruit retention in citrus trees according to Lahey *et al.* (2004) and Ashraf *et al.* (2013) on Kinnow mandarin. In contrast, no significant difference of Jasmonic acid was noticed in citrus flower or fruit set.

Table (2): Effect of some biological stimulants and kaolin particles on initial fruit set (%); fruit retention (%) of Washington navel orange at different periods of development during 2016 and 2017 seasons

Treatments, Conc.		Fruit set (%) 15 DAFB*		Fruit retention (%) DAFB							
				2016				2017			
		2016	2017	03 May	03 June	02 July	15 Oct.	11 May	10 June	10 July	28 Oct.
SA	200 mgL^{-1}	13.22c	14.00c	21.72a	12.19a	7.85a	5.19a	21.99a	11.14b	7.98a	5.36a
	400 mgL^{-1}	14.00b	14.64ab	12.84c	10.59bc	4.10e	2.91cd	19.20b	9.79c	4.64cd	3.10d
JO	2 mlL^{-1}	13.29c	14.52ab	16.27b	11.70a	6.99b	3.90b	16.91c	10.64b	7.02b	4.51b
	4 mlL^{-1}	14.24ab	14.80a	13.18c	9.55d	5.44d	4.05b	15.80d	9.74c	6.41b	4.04bc
RRE	50 mlL^{-1}	14.01b	14.28bc	11.05d	8.89e	3.81ef	3.04c	14.42e	9.32c	4.97c	3.73c
	100 mlL^{-1}	14.57a	14.59ab	12.16cd	11.31ab	3.39fg	2.39cd	13.64e	10.73b	4.19d	3.01d
KPF	5000 mgL^{-1}	12.18d	12.73d	15.74b	10.39bc	6.06c	5.49a	16.60cd	10.93b	6.50b	4.16bc
	10000 mgL^{-1}	13.08c	14.13c	15.46b	10.92b	5.84cd	5.08a	17.35c	12.04a	6.98b	4.15bc
Control		11.10e	12.10e	11.17d	10.14cd	3.14g	2.24d	13.49e	9.47c	4.17d	2.73d
Mean		13.29	13.97	**14.31**	**10.71**	**5.18**	**3.81**	**16.60**	**10.42**	**5.67**	**3.87**
L.S.D at 0.05%		0.95	0.65	**0.95**	**0.65**	**0.53**	**0.71**	**0.97**	**0.76**	**0.62**	**0.60**

Values followed by the same letter within a column are not significantly different at LSD, $P \leq 0.05$ level of probability

* DAFB= Days After full bloom

Fruit yield and fruit number per tree:

Fruit number per tree, fruit weight, yield per tree and per feddan are presented in Table (3). Data showed that SA at 200 mg/l had the highest fruit number per tree (196.75 and 207.50 fruits) in two seasons, respectively compared to the other treatments and control. Preceding results followed by application SA (400 ml/l) where significantly increased fruit number per tree with compared the control in the two seasons. On the other hand, both JO (4 ml/l) and KPF (10000 mg/l) only enhanced fruit number/tree in the first season. In general, all concentrations of biological stimulants and kaolin increased fruit number per tree in both seasons.

Fruit weight as shown in Table (3), indicated that all investigated treatments under study improved fruit weight than the control except salicylic acid at 200 mg/l, which failed to show any significant effect during 2016 and 2017 seasons. The maximum value of fruit weight was achieved with KPF at 5000 mg/l (362.64 and 367.88 g) during two seasons in comparison with the control (325.58 and 331.78 g), respectively. JO at 4 ml/l and/or RRE at 100 ml/l followed KPF treatment in improving av. Fruit weight than that of untreated trees in the two seasons.

SA at both concentrations (200 mg/l and 400 mg/l) and JO (4 ml/l) gave the highest fruit yield per tree (64.56; 64.46 and 66.69 in 2016 season and 69.33; 70.79 and 69.68 in 2017 season), respectively and therefore, increasing productivity for feddan. All used biological stimulants and Kaolin increased navel orange yield expressed as the number of fruit and weight than the control.

These results were in harmony with finding of Ashraf *et al*. (2013) who cited that spraying SA significantly improved fruit yield on Kinnow mandarin trees.

Table (3): Effect of some biological stimulants and kaolin particles on Fruit weight; Fruit number and yield/tree of Washington navel orange at different periods of development during 2016 and 2017 seasons

Treatments, Conc.		Fruit number/ tree	Fruit weight (g)	Yield/tree (kg)	Yield fed^{-1} (ton)	Fruit number/ tree	Fruit weight (g)	Yield/ tree (kg)	Yield fed^{-1} (ton)
		2016	2016	2016	2016	2017	2017	2017	2017
SA	200 mgL^{-1}	196.75a	328.15e	64.56ab	10.85ab	207.50a	334.07f	69.33a	11.65a
	400 mgL^{-1}	186.50b	345.60c	64.46ab	10.83ab	199.75b	354.38bc	70.79a	11.89a
JO	2 mlL^{-1}	167.50de	341.89cd	57.26c	9.62c	173.00fg	347.35d	60.08c	10.10c
	4 mlL^{-1}	187.25b	356.20b	66.69a	11.20a	194.25c	360.25b	69.98a	11.76a
RRE	50 mlL^{-1}	172.00cd	337.25d	58.00c	9.75c	178.75e	341.13e	60.98c	10.24c
	100 mlL^{-1}	177.75c	358.18ab	63.68b	10.70b	183.75d	357.58b	65.70b	11.04b
KPF	5000 mgL^{-1}	174.25c	362.64a	63.19b	10.62b	177.5ef	367.88a	65.30b	10.97b
	10000 mgL^{-1}	184.50b	345.88c	63.82b	10.72b	191.25c	350.05cd	66.95b	11.24b
Control		163.00e	325.58e	53.08d	8.92d	172.00g	331.78f	57.07d	9.59d
L.S.D at 0.05%		6.53	5.93	2.58	0.43	4.81	5.95	1.87	0.31

Values followed by the same letter within a column are not significantly different at LSD, P ≤ 0.05 level of probability

All treatments were beneficial in increasing fruit yield in different ways and mechanisms. Foliar sprays SA on Valencia trees had significantly increased yield, fruit weight, and reducing drop %, owing to salicylic acid effect in enhancing metabolism of plants and biosynthesis during fruit development (Habasy, 2015). Kucuker and Ozturk (2014) cited that preharvest applying methyl Jasmonate on Japanese plums had resulted in higher yield because of its regulatory role in fruit growth and ripening. Foliar application of JO as reported by Iqbal *et al.* (2012) increased fruit weight and this effect is due to enhancing resistance against pests and citrus green and blue molds on tree and that lead to reinvigorating leaves so that photosynthesis will be kept in high rates. The present results contradict the findings of Jifon and Syvertsen (2003) and Zaghloul *et al.* (2017) who concluded that Spraying Balady mandarin with 1, 2, 3, and 4% of KPF increased the yield especially at 4%. This effect may be due to the protective effect of kaolin against high temperature fluctuations and other stresses. In addition to a possible effects in increasing photosynthesis of sprayed leaves. RRE was effective because of its contents of pesticide, antifungal, and antibacterial materials as caffeine and ferulic acids (Gutierrez and Perez, 2004).

Physical characteristics:

Physical fruit characteristics of navel orange are shown in Table (4). Regarding fruit dimensions, data concluded that all treatments caused a significant increase in average fruit length and average fruit width compared to the control. Spraying RRE at 100 ml/l caused the largest increase in fruit length and fruit width (9.33 and 8.60 cm at the 1st season and 9.69 and

8.65 cm at the 2nd season, respectively) compared to the other treatments and untreated ones (8.71 and 8.27 cm and 8.98 and 8.28 cm in both seasons, respectively). In addition, kaolin particle film at 5000 mg/l or JO (4 ml/l) followed by RRE treatment at 100 ml/l in this respect. Fruit diameter slightly and insignificantly improved by salicylic acid sprays, Radish root extract treatment at 50 ml/l and JO (2 ml/l) as compared to the control during 2016 and 2017.

Other treatments resulted in intermediary results of fruit length and width. RRE resulted in higher fruit size and this is consistent with the results of Zarins *et al.* (2009) and that may explain the high growth rate of orange fruits from treated trees.

Table (4): Effect of some biological stimulants and kaolin particles on fruit physical determinations of Washington navel orange during 2016 and 2017 seasons

Treatments, Conc.		Fruit length (cm)	Fruit width (cm)	Secondary fruit diameter (cm	Firmness (kg cm^{-2})	Peel thickness fruit (cm	Fruit length (cm)	Fruit width (cm)	Secondary fruit diameter (cm)	Firmness (kg cm^{-2})	Peel thickness fruit (cm)
		2016					2017				
SA	200 mgL^{-1}	8.92cde	8.31cd	0.89cd	5.14a	0.47b	9.14bc	8.32bc	0.51f	4.12a	0.46c
	400 mgL^{-1}	8.95cde	8.34bcd	0.74f	5.16a	0.44c	9.45ab	8.52abc	0.40g	4.12a	0.45c
JO	2 mlL^{-1}	8.72e	8.49ab	0.98b	5.04ab	0.48b	8.98c	8.43abc	1.25b	4.01ab	0.49b
	4 mlL^{-1}	9.10abc	8.52a	0.99b	4.89bc	0.43cd	9.47ab	8.55ab	1.02c	3.88b	0.45c
RRE	50 mlL^{-1}	8.79de	8.19d	0.63g	4.67de	0.48b	9.07c	8.55ab	0. 63h	3.61c	0.51ab
	100 mlL^{-1}	9.33a	8.60a	1.58a	4.47f	0.51a	9.64a	8.65a	1.46a	3.41d	0.52a
KPF	5000 mgL^{-1}	9.22ab	8.46abc	0.78ef	4.76cd	0.53a	9.52a	8.67a	0.75e	3.34d	0.52a
	10000 mgL^{-1}	8.99bcd	8.49ab	0.91bc	4.54ef	0.42cd	9.43ab	8.42abc	0.90d	3.49cd	0.40d
Control		8.71e	8.27d	0.83de	4.14g	0.41d	8.98c	8.28c	0.77e	3.12e	0.41d
L.S.D at 0.05%		0.24	0.18	0.08	0.19	0.03	0.34	0.24	0.04	0.18	0.02

Values followed by the same letter within a column are not significantly different at L.S.D, $P \leq 0.05$ level of probability

Radish extracts contain cysteine rich peptides and isocyanates which have a certain growth effect and are used commercially in producing plant biostimulants.

Therefore, radish extracts helps in the availability of stimulating conditions, which contribute to improve growth of orange fruits. As for the secondary fruit, it is well known and accepted that the smaller secondary fruit on navel orange, the better the quality of this fruit. After calculation of regression equation, between the fruit weight and the secondary fruit diameter, it was found a weak correlation factor (R=0.27). Radish extract treatment (100 ml/l) resulted in higher fruit weight in both seasons, but accompanied by the highest values of secondary fruit diameter (1.58 and 1.46 cm) for both seasons, respectively.

JO treatment with both 2 ml/l and 4 ml/l and kaolin (10000 mg/l) followed by RRE (100 ml/l) with a big secondary fruit (0.9 – 1.25 cm in diameter).

Fruit firmness (Table 4) was significantly increased by most investigated treatments in both seasons, except with RRE at 100 ml/l in the first season. The highest fruit firmness was determined from trees sprayed with 200 mg/l or 400 mg/l of SA, followed by JO at 2 ml/l treatment than of the check treatment in the two seasons.

Peel thickness (Table 4) of control was lower than all of other treatments fruit recording 0.41 cm in both seasons and similar only to fruits of kaolin treatment at 10000 mg/l. Radish extract (100 ml/l) and kaolin treatment (5000 mg/l) recorded the highest thickness of peel in range from 0.51 to 0.53 cm in both seasons. Most probably used by a higher rate of nitrogen and potassium absorption by the trees as stimulated by spraying radish extract and kaolin treatments (Bevingron *et al.,* 1993).

It can be concluded here that radish extract treatment had resulted in bigger fruits containing a clear secondary fruit, while exogenous application of Jasmonate at early stage of fruits development has protected them against various stresses (Mirdehghan *et al.,* 2012). And that contributes to a regular and optimum fruit growth and consequently, a fruit of high caliber (size) of moderate rind thickness (0.43 – 0.49 cm). SA treatment gave fruits of moderate size but in the second season they have the smallest secondary fruit (0.51 and 0.40 cm for low and high conc., respectively among all treatments.

The high firmness of SA treatment fruit may be explained by the fact that SA may induce a high acquired resistance in plants, which to a vital factor in limiting the injurious effects of abiotic stresses and

inhibiting water loss from fruits. these results are in accordance with those of Ahmad *et al.* (2013) in their work on sweet orange with concentrations of 2, 4, 6, and 8 mm of ascorbic acid and in which the lower concentration 2 mm gave the second highest firmness values of fruit which corroborate the values of fruit firmness related to JO treatment are supported by the similar results obtained by Kucuker and Ozturk (2014) reporting that Jasmonate treated trees of *Prunus salicina* (plums) resulted in higher yields and increasing fruit firmness.

Kaolin sprays on navel orange in this experiment has delayed the ripening processes of orange and these results are in accordance with the work of Zaghloul *et al.* (2017) on Balady mandarin and also are supported by the results of Maletiska *et al.* (2015) on clingstone peach displaying a higher value of firmness for kaolin treated fruits compared to control. Balbontín *et al.* (2018) concluded that application methyl Jasmonate on sweet cherry increased firmness of fruits indicating that Jasmonic acid influences physiological processes of ripening by delaying softening as it is involved in the regulation of cell wall metabolism genes.

SA and radish extract treatments came afterwards with lower and similar firmness values in both seasons. Control fruits were more developed and reached a more advanced stage of ripening, therefore they have the lowest firmness of pulp.

Effect of treatments on juice content, TSS, acidity and vitamin C:

Table (5) showed that there were highly significant differences among the treatments in all studied traits. It clearly demonstrated that the trees treated by SA at 400 mg/L achieved the highest significant values of juice content in both seasons. While, the lowest value of juice content was recorded with application of RRE at 50 ml/L in a comparison with control. It also indicated that the highest TSS percentage and TSS/TA ratio were obtained in trees subjected to foliar application of SA at 200 ml/L followed by SA at 400 mg/L and JO at 2 ml/L during both growing seasons compared to other treatments. In addition, Table 5 showed that the TA (%) was significantly decreased with foliar application SA and RRE compared to untreated trees, whereas the lowest TA was recorded treated trees by SA at 200 mg/l and RRE at 100 ml/L in both seasons. Finally, ascorbic acid as shown in Table 5 indicated that all concentrations of SA, JO at 2 ml/L improved ascorbic content. The highest values were obtained in trees treated with 200 mg/L of SA compared to other treatments.

These results are in agreement with Lahey *et al.* (2004) and Ashraf *et al.* (2013) on kinnow mandarin and El-Gioushy (2016) on navel orange, who found that the SA at different concentration enhanced the chemical characteristics; juice content (%), TSS (%), vitamin C (mg/100g) and decreased citric acid (%).

Table (5): Effect of some biological stimulants and kaolin particles on fruit chemical determinations of Washington navel orange during 2016 and 2017 seasons

Treatments, Conc.		Juice content (%)	TSS (%)	TA (%)	TSS/TA ratio	V.C (mg/100g FW)	Juice content (%)	TSS (%)	TA (%)	TSS/TA ratio	V.C (mg/100 g FW)
		2016					2017				
SA	200 mgL^{-1}	46.76c	10.68a	0.720e	14.84a	45.90a	48.40b	11.16a	0.710d	15.71a	46.75a
	400 mgL^{-1}	49.97a	10.38ab	0.778bcd	13.34b	44.45ab	50.04a	10.76ab	0.795bc	13.54b	45.05abc
JO	2 mlL^{-1}	47.75bc	10.37ab	0.805ab	12.88bcd	44.20ab	48.80ab	10.80ab	0.830ab	13.02b	46.63a
	4 mlL^{-1}	46.24cd	10.03bcd	0.798ab	12.58cd	42.22bc	46.25cd	10.40bc	0.780c	13.35b	44.48bc
RRE	50 mlL^{-1}	44.42de	10.07bc	0.765cd	13.18bc	41.08c	44.45e	10.29bc	0.640e	16.09a	43.92c
	100 mlL^{-1}	49.46ab	9.75cd	0.755d	12.91bc	42.50bc	47.78bc	9.46d	0.730d	12.98b	45.90ab
KPF	5000 mgL^{-1}	46.06cd	9.00e	0.785abc	11.49e	37.91d	45.67de	10.02c	0.725d	13.83b	43.35c
	10000 mgL^{-1}	47.65bc	9.90cd	0.808a	12.26d	42.22bc	47.65bc	10.08c	0.838a	12.02c	45.05abc
Control		44.12e	9.67d	0.768cd	12.63cd	43.51b	45.25de	10.00c	0.840a	11.93c	44.07c
L.S.D at 0.05%		1.83	0.38	0.029	0.64	2.27	1.59	0.51	0.037	0.88	1.71

Values followed by the same letter within a column are not significantly different at L.S.D, $P \leq 0.05$ level of probability

[e]The probability of two genotypes or more having similar SSR profiles

Leaf area index of navel orange leaves:

Data are presented in Table (6) showed that SA at 200 mg/l sprays significantly increased leaf area index, followed by SA at 400 mg/l and kaolin at all of concentrations during two seasons compared with the control. Spraying RRE at 100 ml/l or JO at 4 ml/l markedly enhanced leaf area, but other treatments did not show significant effect than the control.

Leaf chlorophyll value:

As shown in Table (6), leaf chlorophyll values enhanced by all treatments in comparison with the control. The highest increment leaf chlorophyll value was obtained from treatment with KPF (10000mg/l) in both seasons, and RRE at 50 ml/l only in the second season. Leaf chlorophyll value significantly increased affected with spraying SA at 200 mg/l, KPF at 5000 mg/l and RRE at 100 ml/l during 2016 & 2017 seasons. While, the lowest chlorophyll value was obtained from sprays JO (2 ml/l) in two seasons. These results are agreed with those obtained by El-Gioushy (2016) who worked on SA.

Table (6): Effect of some biological stimulants and kaolin particles on leaf area index and chlorophyll value of Washington navel orange during 2016 and 2017 seasons

Treatments, Conc.		Leaf area index (cm^2)		Chlorophyll SPAD values	
		2016	2017	2017	2017
SA	200 mgL^{-1}	36.86a	36.54a	74.01abc	75.98ab
	400 mgL^{-1}	34.70ab	34.64ab	73.07bc	74.19b
JO	2 mlL^{-1}	31.18cd	30.40c	67.41d	70.20c
	4 mlL^{-1}	33.00bcd	33.38b	72.67c	74.60b
RRE	50 mlL^{-1}	29.84cd	29.80c	75.42abc	77.97a
	100 mlL^{-1}	34.00abc	33.34b	75.14abc	76.77ab
KPF	5000 mgL^{-1}	36.15ab	35.70ab	75.87ab	77.15ab
	10000 mgL^{-1}	36.25ab	35.64ab	76.73a	78.03a
Control		31.38d	29.99c	68.36d	70.12c
L.S.D at 0.05%		3.31	2.93	3.17	3.10

Values followed by the same letter within a column are not significantly different at LSD, $P \leq 0.05$ level of probability

Gharaghani *et al.* (2018) mentioned that application of kaolin on Persian walnut trees increased leaf area and chlorophyll content and these results support the findings stated above in this study.

Radish extract effects on having a high chlorophyll content as measured by SPAD may be due to their content of 4-methylthio-3-butenyl isothiocyanate, linoleic acid, monoacylglycerols, glucose and particularly β-sitosterol (Ragasa *et al.,* 2015). In which is a member of the phytosterols very close to brassinosteroids in structure and that may explain the stimulating effect of radish extracts on chlorophyll formation because brassinosteroids promotes increasing chlorophyll content in plants (Yuqin *et al.,* 1994).

Leaf nutrient content (%):

Data in Table (7) indicated that foliar application of KPE and SA at 200 mg/l increased N content in navel orange leaves than that of the control. Spraying kaolin at 10000 mg/l gave the highest N content in leaves compared to untreated ones in the two seasons. All of other treatments moderately enhanced N level content compared to control.

Concerning P content data showed that KPE and SA increased P values than that of the control. However, other treatments slightly improved P content compared with control.

Potassium values in leaves of navel orange increased by RRE at 50 ml/l (0.92; 0.99%) in both seasons and JO at 2 ml/l (0.91; 0.95%) in the 1st season that those of control, respectively, .

Level of Ca content in Table (7) increased by most investigated treatments compared to the untreated trees, except with SA at 400 mg/l and JO at 4 ml/l, where gave the lowest Ca values compared with control. The highest leaf Ca content was obtained from spraying JO at 2 ml/l (6.0 and 6.1%) followed by treatment RRE at 50 ml/l (5.9 and 5.68%) in both seasons, respectively.

The present results are in agreement with El-Gioushy (2016) who stated that SA application enhanced nutritional content at different concentrations of Washington navel orange.

Table (7): Effect of some biological stimulants on leaf nutrient contents (%) of Washington navel orange during 2016 and 2017 seasons

Treatments, Conc.		N %	P %	K %	Ca %	N %	P %	K %	Ca %
		2016				2017			
SA	200 mgL^{-1}	3.31b	0.15b	0.79bc	5.23bc	3.32b	0.15b	0.83e	5.38bcd
	400 mgL^{-1}	2.76f	0.09c	0.68d	4.10e	2.82f	0.09c	0.72h	4.30f
JO	2 mlL^{-1}	3.12d	0.03e	0.91a	6.00a	3.26c	0.03f	0.95b	6.10a
	4 mlL^{-1}	3.24c	0.03e	0.78bc	4.40de	3.17d	0.03f	0.81f	4.68e
RRE	50 mlL^{-1}	3.16d	0.09c	0.92a	5.90ab	3.17d	0.10c	0.99a	5.68b
	100 mlL^{-1}	3.04e	0.04e	0.82bc	4.90cd	3.09e	0.05e	0.87d	5.23cd
KPF	5000 mgL^{-1}	3.31b	0.16b	0.84ab	4.9cd	3.34b	0.16b	0.90c	5.10d
	10000 mgL^{-1}	3.48a	0.30a	0.77bc	5.58abc	3.53a	0.31a	0.87d	5.53bc
Control		2.50g	0.07d	0.74cd	4.30de	2.53g	0.07d	0.78g	4.53ef
L.S.D at 0.05%		0.07	0.02	0.08	0.69	0.03	0.01	0.01	0.33

Values followed by the same letter within a column are not significantly different at L.S.D, $P \leq 0.05$ level of probability

CONCLUSION

Consequently, from the present results clearly approved that Washington navel orange trees treated with salicylic acid (SA) at 200 mg/l enhanced fruit retention, productivity, physico-chemical properties by increasing fruit firmness, juice content, TSS, ascorbic acid, TSS/TA ratio and decreasing acidity. In addition, it improved leaf area index and nutritional status followed by kaolin treatment at all concentrations and JO at 2 ml/l.

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تأثير بعض المنشطات البيولوجية وجزيئات الكاؤلين على الثمار المتبقية والإنتاجية وجودة الثمار في أشجار البرتقال بسرة واشنجطن

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أجريت هذه الدراسة خلال موسمي 2016 و2017 في بستان خاص بمنطقة الصالحية الجديدة، محافظة الشرقية، مصر. تمت على أشجار برتقال بسرة عمر 11سنة منزرعة في ارض رملية وتروى بنظام الري بالتنقيط. تم دراسة تأثير الرش بالسالسيلك أسد بتركيزات 200 و 400 ملجم/اللتر، وزيت الياسمين بتركيزات 2 و 4 مل/ اللتر، و مستخلص جذور الفجل الأحمر بتركيزات 50 و100 مل/ اللتر، ومادة الكاؤلين بتركيزات 5000 و 10000 ملجم/اللتر. وذلك لتقييم تأثيرها على النمو الخضري (المساحة الورقية ومحتوى الأوراق من الكلوروفيل)، ونسبة عقد الثمار، ونسبة الثمار المتبقية، والإنتاجية (المحصول وعدد الثمار ووزن المحصول للشجرة)، وجودة الثمار من حيث وزن الثمرة، أبعاد الثمرة، قطر السرة (الثمرة الثانوية)، سمك القشرة، الصلابة، محتوى الثمرة من العصير، نسبة المواد الصلبة الذائبة الكلية، الحموضة، ونسبة المواد الذائبة الكلية إلى الحموضة، وفيتامين ج، بالإضافة إلى محتوى الأوراق من عناصر النيتروجين والفوسفور والبوتاسيوم والكالسيوم في أشجار البرتقال بسرة واشنجطن. الدراسة الحالية دللت بوضوح أن كل تركيزات السالسيلك أسد خاصة التركيز 200 ملجم/اللتر حسنت المساحة الورقية ونسبة الثمار المتبقية وعدد الثمار على الشجرة والمحصول وصلابة الثمار ونسبة العصير بالثمرة ونسبة المواد الصلبة الذائبة وفيتامين ج مع خفض نسبة الحموضة بالعصير بالإضافة إلى تحسين محتوى الأوراق من النيتروجين والفوسفور. أيضا أوضحت الدراسة التأثير الإيجابي على نسبة الثمار المتبيقة ووزن الثمرة وسمك القشرة والمساحة الورقية ومحتوى الكلوروفيل والنيتروجين والفوسفور بالأوراق عند المعاملة بالكاؤلين. بينما الرش الورقي بزيت الياسمين تركيز 2 مل/اللتر ومستخلص جذور الفجل الأحمر بتركيز 100 مل/اللتر أدي إلي زيادة نسبة عقد الثمار ووزن الثمرة وأبعادها وسمك القشرة معنويا وكذلك محتوى الأوراق من الكالسيوم وخفض نسبة الحموضة.