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Efficacy of Foliar Applications of Salicylic Acid, Zinc and Potassium on Reducing Fruit Drop, Yield Improvement and Quality of Balady Mandarins

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THE OBJECTIVE of the present study was to evaluate the effects of Salicylic acid (SA), Zinc (Zn) and Potassium (K) on reducing fruit drop and improving fruit quality of Balady mandarin (*C. reticulata,* Blanco) at flowering initiation, fruit sized 5 mm and at pre-coloring stage. The experiment was conducted in a commercial orchard in Sharnoob, Behera governorate where 30-year- old trees budded on sour orange rootstock were sprayed with SA at 10mg/L, zinc sulfate at 0.02% and potassium sulfate at 0.25% separately or in combinations. The results showed that K applications alone or combined with SA led to the best results regarding the yield evidenced as fruit number or by weight resulting from markedly increased fruit retention after June drop and final fruit retention percentages. The latter treatment was statistically superior in increasing fruit set followed by Zn or SA solely. All treatments reduced fruit drop, SA separately or plus K or Zn reduced fruit drop than the control treatments. No definite results were obtained concerning fruit physical properties i.e. weight of fruit or peel, fruit length and diameter. However, Zn and Zn plus SA applications significantly increased TSS and TSS/acid ratio, as well as K treatments increased TSS and V.C. as compared to control. Lastly, K or Zn treatments and their combinations with SA resulted in considerable higher values in leaf k and Zn content.

Keywords: Salicylic acid, Potassium, Zinc, Citrus, Fruit set, Abscission.

Citrus is one of the most important horticultural crops in the world as well as in Egypt where it has a tremendous economical impact not only in the local market, but also for export. The harvested area of citrus grown in Egypt is estimated as 530,415 Feddan producing 4,402,180 ton of fruit with an average yield of 9.4 ton/Feddan**)**. Mandarin trees are ranked in Egypt as the second citrus species (22.7%) after orange, representing (21.7%) of total citrus production in 2014 (Anon, 2015).

Fruit set percentage and severity of fruit drop are considered as limiting factors to fruit tree yield. Fruit set was calculated as the percentage of fruits per total remaining flowers and, therefore, is an expression of flower quality or fertility. However, fruit set is also determined by weather conditions during bloom, which affects pollination, pollen tube growth, ovule fertility and plant nutrition (Williams, 1965). Fruit drop in citrus is divided into three main periods for: post bloom drop, June drop and preharvest drop (Lima and Davies 1984). Fruit drop has been considered as a in response to physiological or developmental causes including nutrient disorders either deficient or excess and metabolic processes that represented in carbon availability (carbohydrates or sugars) on both vegetative and reproductive phases (Ruiz *et al.,* 2001 and Iglesias *et al.,* 2003). In addition, (Pozo, 2001) stated that the ratios of growth promoters (Gibberellin) to inhibitors abscisic acid (ABA), jasmonic acid (JA) and ABA or JA –like compounds in floral organs and developing fruits could play a shared role in fruit set and early fruit abscission. Many studies also mentioned that the abscission layer at the stem resulting in fruit drop is formed due to imbalance of auxins, cytokinins and gibberellins (Lahey *et al.,* 2004, Chen & Dekkers 2006 and Balal *et al.,* 2011). Lastly, inadequate environmental conditions like high temperature, water deficits, insect or pest attack and wind velocity of the area (Ibrahim *et al.,* 2007, Razi *et al.,* 2011 and Ashraf *et al.,* 2012) will also contribute to fruit drop. However, fruit drop problems may be lessened by managing water and nutrition for susceptible cultivars and use of approved growth regulators stages (Lima and Davies 1984).

Salicylic acid (SA) classified as a plant hormone-like substances, has been reported to play an important role in the regulation of plant growth and development. It stimulates flowering and tuberization in a range of some angiosperm species, increases flower life, besides improving flowering number or density and fruit set percentages (Kazemi, 2013) and (Mohammadi et al. 2015). The mechanism of salicylic acid was reported by (Oata, 1975) and (Pieterse and Muller 1977), who concluded that salicylic acid induced flowering by acting as a chelating agent. This view was supported by (Raskin *et al.* 1987) and (Ngullie *et al.* 2014) who confirmed that salicylic acid functioned as endogenous growth regulators of flowering and florigenic activity. Exogenous application of SA may influence a range of diverse physiological processes in plants such as ion uptake and transport, photosynthesis, ethylene biosynthesis, fruit yield and quality. Moreover, it can function as ABA inhibitor and regulates the activities of antioxidant enzyme, therefore increase plant tolerance to the a biotic stress (Khan *et al.,* 2003, Karimi *et al.,* 2012, Kassem *et al.,* 2012 and El-Shazly *et al.,* 2013).

Citrus requires big amounts of potassium as compared to other macronutrients (Alva and Tucker 1999). This element is involved in several basic physiological and bio-chemical processes *i.e.* enzyme activation, protein synthesis, sugars and starch formation, stomatal function, stabilization internal pH, photosynthesis, cell division and growth (Liu *et al.,* 2000 and Wei *et al.,* 2002). Application of K was effective in improving fruit set, fruit retention, yield and quality parameters, fruit weight and size, peel thickness, juice volume, TSS% and TSS/acid ratio (Ashraf *et al.,* 2010, 2012 & 2013 a and b) and (ELsabagh, 2012).

Zinc is another important element essential of plant due to its participation in the synthesis of tryptophan which is a precursor of IAA synthesis as well as required for the activity of various enzymes as co- factor, just as dehydrogenases, aldolases, isomerases, RNA and DNA polymerases (Swietlik, 1999). Furthermore, it has a prominent role in starch and nucleic acid metabolisms in plant, and affects photosynthesis reaction likewise protein and carbohydrate biosynthesis (Marschner, 1995 and Alloway, 2008). Application of Zn SO_4 (0.5%) significantly increased final yield in various citrus, grape and pistachio cultivars through increasing fruit set, efficiency of fruiting and decreasing June-drop and pre-harvest drop. In addition, improved physical and chemical fruit properties as well as leaf content of Zn and Mn, (Malik *et al.,* 1993, Dawood *et al.,* 2000 & 2001, El-Baz 2003, Gursoz *et al.,* 2010 and Ashraf *et al.,* 2012).

Due to the important role discussed above that SA, Zn and K plays on fruit set and subsequent fruit drop, an experiment was set to study the influence of foliar applications of them on fruit set, fruit drop percentages, yield and fruit quality as well as in leaf Zn and K content of “Balady” mandarin trees.

Materials and Methods

The present trial was conducted on thirty-years old Balady mandarin trees (*C. reticulata,* Blanco) budded on sour orange rootstock planted in a private orchard at Sharnoob Village, El-Behera Governorate. Trees received the regular horticultural practices usually carried out in the orchard.

This experiment included the following treatments throughout 2013 and 2014 seasons.

- Spraying SA at 10 mgL^{-1}.
- Spraying zinc sulfate at 0.02%.
- Spraying potassium sulfate at 0.25%.
- Spraying SA +Zn at (10 mgL^{-1}+ 0.02%).
- Spraying SA+K at (10 mgL^{-1}+0.25%).
- Spraying SA+Zn+K at (10 mgL^{-1}+0.02%+0.25%).
- Control (tap water).

A wetting agent, in this case, True Film (produced by Eropic Group) at rate of 8 cm/20L water was added to all sprayed applications to obtain better foliar absorption.

All selected trees were sprayed till run off three times: , at flowering initiation (late March), at fruit set sized 5 mm in diameter (Mid May) and when fruits were at the pre-coloring stage (Late September). Three branches were selected from different sides of each tree: Total number of flowers at full bloom and fruitlet formed after two weeks of full bloom for each tagged branch were counted and calculated according to the formula of (Ashraf *et al.,* 2013a).

- Fruit set (%) = total number of fruitlet / total number of flowers.
- Fruit retention (%) =No. of fruits after June drop/ total number of fruitlet.
- Fruit drop (%) = 100 – Fruit retention (%).
- Final Fruit retention (%) = No. of fruits at harvest/ total number of fruitlet.
- Preharvest drop (%) = 100 – % final fruit retention.

Yield was recorded at harvest date in December of 2013 and 2014 seasons, expressed as weight (kg/tree) and number of fruits per tree.

Fruit physical and chemical properties were also tested in ten fruits randomly harvested from all sides of trees in which the following parameters determined according to methods described by A.O.A.C. (1985) were registered, rind (%) fruit weight, length, diameter and fruit shape as well as TSS%, Acidity, TSS/acidity ratio and vitamin C (mg/100ml juice) were determined.

Fully mature leaves of Spring non- fruiting shoots were collected randomly in October from treated trees and leaf K and Zn content was determined according to Chapman (1960) and Chapman and Pratt (1978).

The collected data were laid out in a Randomized Complete Block Design with four replicates, using computer software SPSS. Treatment means were compared by least significant differences test (LSD) at 5% at level of probability.

Results and Discussion

Fruit set (%)

Data showed in Table 1 revealed that foliar applications of SA in a mixture with K treatment were statistically superior in fruit set percentage compared to either K, SA+ Zn and control on the first year or K, SA+K+Zn and control in the 2nd year, followed by spraying separately with zinc or SA as compared with other treatments and control in 2013 and 2014, respectively. Moreover, the triple treatment which included SA, Zn, and K recorded intermediate values between zinc spraying treatment alone and in mixture with SA in first season or between K foliar separately and involved in SA in second season. Our results are in agreement with those reported by (Ashraf *et al.,* 2012 & 2013a) on Kinnow mandarin, who found that the fruit set percentage per tree was significantly improved with foliar applications of SA in combination with K as compared with SA in mixture with Zn or K alone. They also mentioned that trees sprayed with triple combination recorded higher values of fruit set (%) than those treated with SA only, which is not our case in which those does not differ significantly in the first year or even the reverse in the second cycle. In addition, the presented results could be supported by those obta sweet orange, (Sarrwy *et al.,* 2012) on Balady Mandarin and (Soliemanzadeh *et al.,* 2013) on Pistachio trees. They stated that foliar application of Zn in various concentrations increased the final fruit set as compared with control, moreover these results partially agreed with the findings of (Habasy, 2015) working on Valencia orange and (Ahmed *et al.,*

2014) on Kiette mango, who found that spraying with SA alone enhanced initial fruit setting (%) as compared with control. Although nutrients do not regulate growth, meanwhile hormones do, it was evident from the results of present work, that K in a mixture with SA had more positive effect in fruit setting,. Since potassium is not a hormone it can not stimulate flowering but his role may be linked an increase in fruit set as indicated in a number of species such as lemon, probably due its role as a primary component of cell walls. This explains that the maximum effect of foliar K is achieved by applications that make this important nutrient available during bloom and post-bloom when it can be used during both cell division and rapid cell enlargement phases (Zekri and Obreza, 2012). ined by (Abd El-Motty *et al.,* 2006) on Valencia orange, (Sajid *et al.,* 2010) on

TABLE 1. Effect of SA, Zn and K foliar Sprays on Fruit Set, Retention or Drop Percentage.

Treatment	Fruit Set %	Fruit Retention after June Drop (%)	June drop (%)	Final Fruit Retention (%)	Pre-harvest fruit drop (%)
2013					
SA	28.24	33.34	66.66	14.62	85.38
Zn	29.64	15.28	84.72	15.00	85.00
K	22.24	46.67	53.33	44.90	55.10
SA + Zn	20.38	18.83	81.18	14.70	85.29
SA + K	32.78	23.25	76.76	22.62	77.38
SA + Zn + K	28.58	24.19	75.81	15.91	84.09
Control	15.86	12.11	87.90	9.36	90.63
L.S.D	10.47	5.88	5.88	6.21	6.21
2014					
SA	24.91	14.68	85.32	9.21	90.88
Zn	23.34	11.67	88.33	11.28	88.72
K	13.08	36.32	63.68	26.81	73.19
SA + Zn	19.46	14.70	85.30	13.50	86.50
SA + K	25.48	21.65	78.35	21.37	78.63
SA + Zn + K	17.02	23.86	76.14	12.12	87.88
Control	8.68	9.64	90.36	8.56	91.44
L.S.D	8.08	7.97	6.21	4.34	6.35

As indicated in the introduction the positive effects observed in the results of this experiment may indicate that the physiological role of salicylic acid as phytohoromone and potassium as essential nutrient in increasing fruit set complementary to each other. The partially higher fruit set%, results obtained with zinc foliar application appeared in probably due to acting as integral role in auxin synthesis, which is responsible for cell elongation and growth. Finally, accordingly with (Beede *et al.,* 1989) and (Karimi *et al.,* 2012) who stated that inflorescence bud retention was the highest by application of SA and Zn the good results obtained with the combinations of both treatments may be a consequence of improving chances of occurrence of flowering, pollination and fruit set.

Fruit retention and drop (%)

Concerning the data in Table 1 it is obvious that spraying K separately recorded the highest values in both fruit retention periods after June-drop and at the final fruit retention percentages, closely followed by K in combination with SA from which significantly differs for final fruit retained till harvest in both years, as well as SA alone or in mixture with Zn and K led to higher response to retained fruit after June- drop% in both seasons under study. Moreover, the maximum increment rate over control reached 2.85 (46.67- 12.11/ 12.11) and 2.77 in retained fruit after June-drop or 3.80 and 2.13% in final fruit retention that obtained from K application individually in 2013 and 2014 seasons, respectively. It is quite obvious from the data shown in Table (1), that all K foliar applications either alone or in a mixture with SA or triple combination with SA and Zn positively affected fruit June-drop by decreasing it as well as preharvest drop percentages during both seasons. Moreover, spraying with SA separately or combined with Zn low significantly percentages of fruit June-drop% as compared with control in 2013 only. The minimum reduction rate over control was 0.39 (87.90-53.33 / 87.90) and 0.30 in June-drop% or 0.39 and 0.20 in preharvest drop% in 2013 and 2014, respectively. The present results regarding fruit drop or fruit retention percentages are in harmony with those reported by (Ashraf *et al.,* 2010 & 2012 and 2013a), foliar application of SA, K or Zn and their mixture reduced fruit drop% and increased fruit retention%, especially K treatment and its combinations with SA only or SA and Zn gather were superior in improving fruit retention% as well as controlling fruit drop% as compared with control or other treatments. Also, (Hegazi *et al.,* 2011) on olive and (Stino *et al.,* 2011) on mango concluded that K spraying either twice during growth season or at bud emergence, full bloom or pea stage reduced fruit drop and increased fruit retention%. Generally, these results are partially in harmony with the findings of (Chen and Dekkers, 2006) on sweet orange and grapefruit, (Sajid *et al.,* 2010) on Blood orange, (Sarrawy *et al.,* 2012) on Balady mandarin and (Ashraf *et al.,* 2013a) or (Razzaq *et al.,* 2013) on Kinnow mandarin, they all elucidated that SA or Zn foliar applications solely in different concentrations were effective in decreasing fruit June-drop or preharvest drop, consequently improving fruit retained after June-drop or final fruit retention. (Iglesias *et al.* 2003) mentioned that indirect evidence proved a clear relationship between sucrose supplementation and decreased fruitlet abscission rate and increased fruit retention before and during June –drop in partially defoliated and non-defoliated trees, therefore K contribute in improving fruit retention may be due to it is essential in carbohydrates metabolism and formation or translocation of starches and sugars. In addition, (Kuang *et al.* 2012), suggested that carbohydrates and auxin participate in complex signal transduction pathway involved in fruitlet abscission. As for SA was beneficial in possibility of promoting fruit retention by interfering ethylene biosynthesis or action, which in turn reduced fruitlet abscission and enhanced harvestable mango fruits (Ngullie *et al.,* 2014). Other insight reported by (Chen and Dekkers, 2006) salicylic acid (SA) suggested that is inhibitor of Jasmonic acid (JA) biosynthesis and function, that it plays essential roles in young fruit abscission, therefore application of (SA) on sweet orange or grapefruit controlled young fruit drop and resulted in higher of fruit retention. Finally, (Lima and Davies, 1984) reported that fruit drop problems may be lessened by managing water and nutrition for susceptible cultivars and use of approved growth regulators.

Yield

Observations regarding data shown in Table 2 clearly exhibited that yield as fruit number or weight (kg) per tree was influenced with K treatment alone which differs significantly from all the other tratments or in association with SA which also differs statiscally form the other ones as for fruits number per tree and yield (kg/tree) in both seasons. Mostly, trees sprayed with SA+K+Zn Zn or SA showed higher showed higher yield as fruits number or weight per tree in comparison with control and the significant differences appeared in the 2^{nd} year. It was observed, in the present study that results of foliar applied potassium affect positively yield in citrus through increasing retained fruit after June drop or final fruit retention and agreed with (Ashraf *et al.,* 2010 & 2012) on citrus, Stino *et al.,* 2011) on mango, (Abd El-Migeed *et al.,* 2013) and (Elsabagh, 2012) on date palm, (Erner *et al.* 1993) reported that potassium spraying is potent tool to increase yields of various citrus species, meanwhile zinc impact in improving yield is due to increase fruit set% that confirmed with those of (Dawood *et al.,* 2000), (El-Baz 2003), (Abd El Motty *et al.,* 2006), (Hafez & El-Metwally, 2007) and (Sajid *et al.,* 2010), in addition SA acid affects fruit set and fruit drop percentages mediately in between Zn and K that agreed partially with those of (Ashraf *et al.,* 2012 & 2013a) and (Kassem *et al.,* 2012). The considerable improvement in final yield resulted in increased fruit set, efficiency of fruiting and decreasing June-drop and preharvest drop (Hafez and El-Metwally, 2007). In the light of previous results, might be the enhancement in yield of Balady mandarin as fruit number or weight due to potassium or zinc is due to the involvement of these elements in carbohydrates biosynthesis, starch formation and sugars translocation, Moreover, the significant increment in yield as fruits number or weight /tree obtained with K, Zn or SA spraying may be, as indicated by Hafez and El-Metwally (2007) and Ngullie *et al.,* (2014) may be ascribed to an enhance of the activity of photosynthesis, nucleic acid metabolism and carbohydrate or protein biosynthesis in leaves, which in turn encourage plant growth that reflected in promoting yield.

Leaf Zn and K content

Regarding results in Table 2 they demonstrated that K sprays separately or combined with SA only recorded significant higher percentages of leaf K content in comparison with Zn or Zn +SA and control treatments in both seasons, beside spraying SA separately affect leaf k content with differences were big enough to be significant in first years. On the other hand, zinc treatments alone or combined with SA were concomitant with significant higher leaf zinc content in both season. Our results are supported by other published papers earlier by Hafez and El-Metwally (2007), Sarrwy *et al.* (2012), Khan *et al.* (2012), Razzaq *et al.* (2013) and (Ashraf *et al.,* 2013b) on different citrus species and Soliemanzadeh *et al.,* (2013) on Pistachio trees. They reported that foliar Zn and K applications in various either form or concentrations improved Zn and K uptake which in turn was reflected in an increment leaf K and Zn content. Moreover, our results partially agreed with Potassium concentration of leaf was unaffected by SA treatment, whereas it was more responsive by foliar K according to (Karimi *et al.,* 2012) on Pistachio trees.

TABLE 2. Effect of SA, Zn and K foliar Sprays on Yield, Leaf Zn or K Contents.

Treatment	**Yield**		**Leaf K content (%)**	**Leaf Zn content (ppm)**
	No. fruit/ tree	**(kg/ tree)**		
	2013			
SA	315.00	20.48	0.99	77.96
Zn	243.00	13.57	0.78	89.14
K	657.50	40.92	1.07	72.76
SA + Zn	224.50	14.00	0.72	88.13
SA + K	471.00	31.02	1.03	54.49
SA + Zn + K	289.50	20.79	0.89	82.20
Control	175.00	12.38	0.64	67.50
L.S.D	**121.08**	**7.43**	**0.18**	**17.79**
	2014			
SA	396.00	46.79	1.01	74.10
Zn	442.00	52.84	0.90	90.82
K	533.00	72.26	1.10	69.96
SA + Zn	295.50	32.18	0.88	92.35
SA + K	517.00	68.23	1.09	64.15
SA + Zn + K	448.00	54.50	1.05	87.99
Control	240.50	26.62	0.69	73.66
L.S.D	**130.15**	**16.72**	**0.17**	**25.03**

Fruit quality

A-Physical fruit properties

Data of the present investigation in Table 3 showed that fruit weight did not significantly differ between all foliar applications and control in season 2013 only, but otherwise trees treated with potassium and its combination with SA alone produced the heavier fruit in both seasons with significant difference only in 2014. In addition, applications of foliar SA and Zn solely or as combined treatment did not affect fruit weight than control. Nearly similar results were observed concerning peel weight %. The examined treatments did not affect significantly to peel % in both season, however K foliar application alone or in combinations resulted in fruits with thinner peel as compared with control, although not differs statistically. Applications of SA, Zn, and K separately or in combinations increased fruit juice volume or content as compared with control in both seasons, with bigger differences in season 2014 only. Data concerning fruit length showed no consistent trend according to different spraying treatments, the highest values of fruit length were obtained by spraying K in combination with Zn plus SA in 2013 but only significantly different from the control and either K or Zn separately in 2014, but in this season all them, except barely SA+K+Zn differs significantly form it. As for fruit diameter or size and fruit shape, generally results demonstrated that the increment of both traits value was slight to be significant except K foliar in mixtures with SA + Zn produced the largest fruit size as well as using Zn or Zn+SA treatments recorded the highest values of fruit shape in 2013 only. The unexpected result of control giving the heaviest fruits in 2013, despite not being significantly different from the treatments only might be due to the fact that the control produced the significant least number of fruits that provides chance for best fruits growth (unfortunately this was not recorded). Present results are in agreement with those of Lavon *et al.* (1995), Hafez and Metwally (2007), Ashraf *et al.* (2010), Abd El-Rahman *et al.* (2012), Sarrwy *et al.* (2012), Khan *et al.* (2012), Fernandez & De Guzman (2013), Abd El-Motty & Orabi (2014), Razzaq *et al.* (2013) and Aly *et al.* (2015) on different citrus species and Kassem *et al*. (2011) on Jujube, Abd El-Migeed *et al.* (2013) on date palm, (El-Shazly *et al.,* 2013) on peach and (Ngullie *et al.,* 2014) on mango. They all concluded that K foliar applications increased fruit length, diameter and weight or fruit juice content and decreased either peel weight % or thickness, while spraying of SA or Zn had no significant effects on fruit weight and peel weight % or thickness and increased fruit length, diameter and juice content. Furthermore, our results regarding fruit juice volume partially agreed with finding of Ashraf *et al.* (2012), who reported that spraying of SA, Zn, K or their combinations significantly increased fruit juice volume especially K and its mixtures. The improval of physical fruit properties i.e. fruit weight, length, diameter, peel weight and fruit juice content could be due to improve cell size and number through nutrient enhance fruit growth and uptake of nutrients accelerating metabolic processes on line with the observations of Abd El-Migeed *et al.* (2013), and Harhash & Abdel-Nasser (2010), (Elsabagh, 2012) on date palm, which mentioned that potassium increase the rate of sugar transport to activity growing region and also in developing fruits.

TABLE 3. Effect of SA, Zn and K foliar Sprays on Physical Fruit Properties.

Treatment	Fruit Weight (g)	Peel Weight (%)	June Volume (ml)	Fruit Length (cm)	Fruit Diameter (cm)
2013					
SA	65.03	21.33	198.33	5.65	6.63
Zn	55.83	17.28	206.67	5.88	6.35
K	62.24	27.11	215.00	5.92	6.80
SA + Zn	62.39	22.79	225.00	5.95	6.38
SA + K	65.86	32.43	211.67	5.93	6.27
SA + Zn + K	71.81	29.33	224.67	6.10	7.05
Control	74.40	17.59	176.67	5.55	6.78
L.S.D	**22.00**	**18.13**	**39.09**	**0.46**	**0.59**
2014					
SA	118.16	24.72	146.67	5.06	6.21
Zn	119.54	26.29	126.67	5.82	6.11
K	135.56	23.73	200.00	5.64	6.47
SA + Zn	108.90	20.70	130.00	5.41	6.27
SA + K	131.98	21.62	180.00	5.26	6.04
SA + Zn + K	121.66	23.04	136.67	5.20	6.16
Control	110.69	25.50	85.00	4.74	6.12
L.S.D	13.17	3.54	31.90	0.496	0.49

TABLE 4. Effect of SA, Zn and K foliar Sprays on Fruit shape or Chemical Fruit Properties.

Treatment	Fruit Shape	V.C (mg/ 100ml Juice)	TSS (%)	Acidity (%)	TSS/ acid ratio
	2013				
SA	0.85	37.35	10.75	1.10	9.77
Zn	0.93	38.95	11.50	1.07	10.80
K	0.87	43.72	11.10	1.04	10.41
SA + Zn	0.94	41.60	11.50	1.01	11.38
SA + K	0.91	45.14	11.00	1.12	9.82
SA + Zn + K	0.86	44.25	11.25	1.16	9.74
Control	0.82	36.46	10.50	1.08	9.54
L.S.D	0.091	5.27	0.57	0.077	0.87
	2014				
SA	0.82	35.10	12.35	1.02	12.10
Zn	0.95	38.43	12.60	1.16	10.88
K	0.87	38.86	11.85	1.12	10.28
SA + Zn	0.87	37.44	13.30	1.15	11.61
SA + K	0.87	42.59	12.53	1.24	10.14
SA + Zn + K	0.85	42.12	12.45	1.34	9.46
Control	0.78	32.78	10.95	1.10	9.44
L.S.D	0.060	5.07	0.90	0.08	1.08

Chemical fruit properties

Fruit vitamin C was affected positively with Zn, K, SA and their combinations particularly K involved in SA or SA and Zn gather which differ significantly from the control in 2013 and all of the treatments except SA and SA+ Zn in 2014. These results are supported by Hafez and Metwally (2007), Ashraf *et al.* (2012 & 2013a), Khan *et al.* (2012), Sarrwy *et al.* (2012), Abd El-Motty & Orabi (2013) and Razzaq *et al.* (2013) and on various citrus and (Kassem *et al.,* 2011) on Jujube. They all reported that Zn, k or SA in different forms and concentrations either separately or in combinations had beneficial effect in increasing ascorbic acid content in the juice. (Holler *et al.*, 2013) stated converting l-galactose to Ascorbic acid (AsA) which is inactive under low Zn stress, therefore they suggested hypothesis, Zn deficiency inhibits AsA biosynthesis in the intolerant genotype. Meanwhile, Alloway (2008) and Nawaz *et al.* (2008) reported that Zn is prerequisite of auxin in plant species, as the production of auxin increases ascorbic acid content in Kinnow mandarin fruits. On the other direction, Dat *et al.* (1998) found that salicylic acid activates ascorbate peroxidase, which increases antioxidant ability and ascorbic acid amount and prevents vitamin C destruction in fruits. Furthermore, Watson *et al.*, (1946) and Ibrahim *et al.* (2012) they found that ascorbic acid content increased under high K application levels in L. pumila seedlings might possibly be attributed to high production of total non structural carbohydrate (TNC) under high K application, this is because TNC (D-glucose) is a precursor for ascorbic acid biosynthesis in plants, as more availability of TNC more ascorbic acid would be produced in the L-galactose pathways. Screening of mechanisms of SA, K and Zn in increasing ascorbic acid in fruits and observed the synergistic effect between them reflected on SA in combination with K and Zn foliar application achieved higher ascorbic acid content. It was clear from our data that foliar all applications increasing significantly in TSS% compared to control in both cycles except SA in 2013 beside Zn alone or combined with SA recorded higher values in both year then SA+K+Zn or SA+K in 2013 and 2014, respectively. These results agreed with those of Khan *et al.* (2012), Abd El-Motty & Orabi (2014) and Razzaq *et al.* (2013). They mentioned that spraying Zn alone in lower different concentration markedly increased TSS% in citrus fruit juice, also (Ashraf *et al.,* 2012) they observed that foliar K involved in SA alone or SA and Zn resulted in higher TSS% than SA or k solely. Mostly, no clear trend was observed regarding juice acidity that was not or slightly affected except SA+K or SA+K+Zn gave higher acidity with significant differences in 2014 only as compared with control and the rest of treatments. Our results partially agreed with those of Abd El-Motty and Orabi (2014), Ashraf *et al.* (2013) and Razzaq *et al.* (2013) on citrus, Asghari (2006) on strawberry, (Kassem *et al.,* 2011) on Jujube and (Abd El-Migeed *et al.,* 2013) on date palm they all reported that spraying SA, K or Zn separately did not significantly influence citric acid . Higher ratio of TSS/acidity in response to foliar Zn sprays either alone or in mixture with SA followed by K separately or plus SA in both seasons. In addition SA treatment appeared to have significant effect in this trait in 2014 only as compared with control. These results are in line with (Hasani *et al.,* 2012) on pomegranate, (Ashraf *et al.,* 2012 & 2013b) on mandarin and (Ahmed *et al.,* 2014) on mango, they mentioned that TSS/acid ratio of juice increased with applications of Zn, K, and SA alone or in combinations as compared with control and other treatments. As indicated in the introduction, the positive effects of foliar Zn feeding and its combinations resulting in higher TSS% might be due to possible increase of activity of the hydrolyzing enzyme mannose/l-galactose by the application of zinc and resulted in increased breakdown of polysaccharides into simple sugars and is on line with (Brahmachari and Rani, 2001). On contrary, (Ibrahim *et al.,* 2012) mentioned that there was more accumulation of starch than soluble sugar in L. pumila plants fertilized with high K without impairment of photosynthesis. Our results showed that acidity values were increased by the treatments which contained SA which may be explained by the function of SA which delayed ripening and therefore the consequent reduction in metabolic changes of organic acid into carbon dioxide and water as indicated by Pila *et al.* (2010) and Abdel-Salam (2016). The significant higher ratios of TSS/acid registered by foliar Zn only or in combination with SA may probably be due to the fact that Zinc has an important role in photosynthesis and related enzymes, resulting in increasing sugar and decreasing acidity, as well as spraying of salicylic acid regulated the carbohydrate metabolism in both source and sink tissue of the plants (Ngullie *et al.,* 2014).

Conclusion

Generally, results of the current study proved that K, Zn, SA and their combination, mostly were effective either in enhancing fruit set% and fruit retention or in reducing fruit drop% as compared with control. Combination between K and SA had more synergetic effect than others in yield increment. On the other hand, Zn or Zn plus SA improved chemical fruit properties, besides leaf K or Zn content significantly influenced due to spray K or Zn alone or in combinations with SA.

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دراسه فاعليه الرش الورقى بحمض الساليسيليك والزنك والبوتاسيوم على تقليل تساقط الثمار وتحسين المحصول والجوده فى اليوسفى البلدى

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كان الهدف من هذه الدراسة لتقييم تأثير حمض الساليسيليك (SA) والزنك (Zn) والبوتاسيوم (K) على الحد من تساقط الثمار وتحسين كل من محصول و جودة الثمار اليوسفى البلدى، في ثلاث مراحل بدء الازهار (أواخر مارس) والثمار العاقده بحجم الحجم ٥ مم (منتصف مايو) وفي مرحلة ما قبل التلوين (أواخر سبتمبر). وقد أجريت التجربة بمزرعة خاصه فى قريه شرنوب بمحافظة البحيره. تم رش اشجار اليوسفى عمر ٣٠ عاما والمطعمه على أصل النارنج بحامض الساليسيليك بتركيز (10ملجم/ لتر) كبريتات الزنك عند ٠.٠٢٪ وكبريتات البوتاسيوم عند ٠.٢٥٪ كلا على حدة أو في تداخلات بيتهم. وأظهرت النتائج أن التطبيقات K بمفرده أو مجتمعة مع SA أدت أفضل النتائج للمحصول سواء كعدد الثمار / شجره او بالوزن (كجم)/ شجره والناتجة عن زيادة ملحوظة فى نسبتى بقاء الثمار بعد تساقط يونيو او المتبقيه ما قبل الحصاد والنهائية، وكانت المعامله الاخيره متفوقة إحصائيا في زيادة نسبه عقد الثمار تليها الزنك أو SA منفردا. كل المعاملات خفضت تساقط الثمار،وكانت معاملات حمض الساليسيليك بشكل منفصل أومتداخل مع البوتاسيوم أو الزنك يقلل النسبه المئويه لتساقط الثمار مقارنه بمعامله الكنترول. لم يتسن التوصل إلى نتائج مؤكدة بشأن خصائص الفاكهه الطبيعيه أي (وزن الفاكهة أو قشر، طول الثمرة وقطرها). ومع ذلك أدت معاملتى الزنك بمفرده او متداخلا مع حمض الساليسالسك زيادة كبيرة فى نسبه المئويه للمواد الصلبه الذائبه و نسبه المواد الصلبه الذائبه. زادت معاملات البوتاسيوم وتداخلاته الى زياده واضحه فى محتوى عصير الثمار من فيتامين سى أخيرا، أخيرا أدت معاملات البوتاسيوم والزنك وتداخلاتهم مع حمض الساليساليك الى زياده معنويه فى محتوى الاوراق لكلا من البوتاسيوم والزنك.