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Effect of Some Pre-harvest Treatments on Yield and Fruit Quality of "Swelling" Peach Trees

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Abstract

This study was carried out during the two successive seasons of 2016 and 2017 in order to study the effect of some pre-harvest treatments. i.e. ascorbic acid (AsA), citric acid (CiA), salicylic acid (SA) each at (400 and 600 ppm), gibberellic acid (GA_3) at (50 and 100 ppm), and calcium chloride ($CaCl_2$) at (1 and 2%(w/v)) on the yield and fruit quality of nine years old Swelling peach trees (***Prunuspersica*** L.) growing in sandy soil,under drip irrigation system. Results showed that GA_3 at 100 ppm and $CaCl_2$ at 2 % gave the highest values of total yield,also GA_3 at 100 ppm significantly increased fruit weight, size and fruit firmness as compared with other treatments in both seasons. Both AsA and CiA at 600 ppm caused the highest increase in TSS % ,total sugars andanthocyanin contents, while both AsA at 400 and 600 ppm and CiA at 600 ppm were caused increasing in fruit TSS/ acid ratio in both seasons. Meanwhile, GA_3 at 100 ppmsignificantly increased fruit acidity, chlorophyll a and b contents as compared with the other treatments. Generally, it could be concluded that, gibberellic, salicylic acids and calcium chloride markedly increased yield, fruit firmness and fruit chlorophyll a and b content as compared with all other treatments.

Key words: fruitfirmness, anthocyanin, foliar spraying, GA_3, $CaCl_2$and antioxidants.

Introduction

The peach (***Prunuspersica*L.**) is one of the most important stone fruits, due to its heavy loading, dietetic value and as a rich source of carbohydrate and vitamins especially (A, B and C) and some mineral nutrients. According to **(FAO, 2016)**, the area cultivated with peach in Egypt is 48985 feddans, and the total product of peach fruits is 266628tons. Swelling peach is one of the late season cultivars that suffer fromaccelerated softened fruits, and therefore, the fruits exhibits short handling period, which limits its commercial potential. This concept obligates fruit producer to harvest fruits at early ripening stage. Accordingly, there is a great need to decrease fruit deterioration after harvest and to enhance fruit quality in order to prolong the handling season with acceptable yield. To reach this goal some antioxidants and chemicals can be used such as ascorbic, citric, salicylic acids, and gibberellic acids, and calcium chloride. Ascorbic, citric and salicylic acids are considered as auxinic action, since they have a synergistic effect on growth and productivity of most fruit trees **(Ragab, 2002)**. In addition, the positive action of antioxidants in catching or chelating the free radicals, which could result in extending the shelf life of fruit cells and stimulating growth aspects was reported by **(Raoet al., 2000)**. In the meantime, ascorbic acid is considered a regulator of plant growth. Also, citric acid plays an essential role in signal transduction system, membrane stability and functions, activating transporter enzymes, metabolism and translocation of carbohydrates **(Smirnoff, 1996)**. Salicylic acid (SA) is an endogenous growth regulator from phenolic group, which participates in the regulation of several physiological processes in plants such as growth and development **(Asghari and Aghdam, 2010)**. It prevents fruit softening by affecting activities of major cell wall degrading enzyme such as cellulose, polygalactouronase and xylanase **(Zhang et al., 2003)**. Using salicylic acid was very effective in enhancing yield and fruit quality of peach fruits**(Elshazly et al., 2013)**. Gibberellins are a group of growth substance, which are known to delay ripening and senescence of fruits **(Khader, 1992)**. The site of ethylene inhibition by gibberellic acid appeared to be related to the ethylene forming enzymes**(Ben and Ferguson, 1991)**. Calcium is a nutrient that plays an important role in improving fruit quality. also it is confer rigidity of cell walls, which in turn reflected on increasing the tissue firmness,**(Rizk-Alla et al., 2006)**. The present investigation aimed to study the effect of some antioxidants (ascorbic, citric and salicylic acids) as well as, gibberellic acid and calcium chloride sprays on yield and fruit quality of Swelling peach trees grown in sandy soil, under drip irrigation system.

Materials And Methods

The present study was carried out during 2016 and 2017 seasons on 66 trees (11 treatments x 3 rep. x 2 trees)of (***Prunuspersica*** L.) Swelling peach cultivar grafted on Nemagaurd rootstock grown in a privateorchard located at El-Khatatba, Menofya Governorate, Egypt.Trees were about 9 years old planted 5 x 5 m apart, grown in sandy soil, under dripirrigation system and the trees received their normal cultural practices which usually applied in commercial orchards. The selected trees were healthy, uniform in shape and size.The trees were sprayed to the run off at the pit hardening end of April in both studied seasons. Control treessprayed with water only.Tween-20 (0.1 %) as surfactant was added to all spraying solutions andapplied directly for the trees with a handheld sprayer until runoff in the early morning.Preharvest treatments as follows:

No.	Treatments	Concentrations
1	Control(sprayed with water only)	
2	Ascorbic acid (AsA) at	(400 ppm)
		(600 ppm)
3	Calcium chloride (CaCl2) at	(1 %)
		(2 %)
4	Citric acid (AsA) at	(400 ppm)
		(600 ppm)
5	Gibberellic acid (GA3) at	(50 ppm)
		(100 ppm)
6	Salicylic acid (SA) at	(400 ppm)
		(600 ppm)

Peach fruits were harvested at predictable maturity stageaccording to**Aly, (1988)**. Samples of10 mature fruits were taken from each tree of treatments for determining the yield and fruit quality. Fruit yield/tree (kg) for each treatment was estimated in both seasons. Fruitstransported to the laboratory to determine the physical and chemical fruit characteristics.Average fruit weight (g) and fruit volume (cm^3) were determined. Fruit firmness ($lb/inch^2$) was measured using a pressure tester (digital force-Gouge ModelIGV-OSA to FGV-100A.Shimpo instruments). TSS **(%)** was measured by a handrefractometer,juice acidity(%) was measured as malic acid as outlined in **(A.O.A.C, 2005)**. TSS/acid ratio was calculated. Total sugar content (%) was determined in fresh fruit sample according to **Malik and Singh (1980)**. Chlorophyll a and b (mg/100g) content were determined according to **Lichtenthaler and Wellburn (1983)**. Anthocyanin (mg/100g) content in fruit peel was determined according to the methods of **(Mazumdar and Majumder, 2003).**

Statistical Analysis: A complete randomized block design was followed and the analysis of variance (ANOVA) was performed using ANOVA Co-stat software, treatment means were compared withan LSD range test at the 5% level of probability according to **Steel and Torrie (1984).**

Results And Discussion

The yield.

Datapresented in table (1) indicated that, in both seasons, gibberellic acid (GA_3 at 100 ppm)and calcium chloride ($CaCl_2$ at 2 %)treatments significantly increased yield as compared with all other treatments in the two seasons. Moreover, no significant differences in the yield between AsA, CiA and SA at concentrations (400 and 600 ppm) and $CaCl_2$at (1 %),while control treatment gave the lowest yield in both seasons. These results were in line with those obtained by **(Elshazly et al., 2013)** on peach, who found that yield was generally improved by GA_3 foliar spray. The increase in yield obtained by GA_3treatments might be due to that GA_3stimulates cell division and cell enlargement, which reflects on increasing fruit weight and consequently fruit yield **(Abdelmoneim et al., 2007).** Gibberellic acid creates sink strength in the fruit cells, thus attracts water and nutrients.

Table 1. Effect of some pre-harvest treatments on yield of Swelling peach trees during 2016 and 2017 seasons.

Treatments		**Yield / tree (kg)**	
		2016	**2017**
Control		**32.03**	**34.20**
Ascorbic acid (AsA) at	**(400 ppm)**	**37.75**	**39.92**
	(600 ppm)	**39.40**	**41.57**
Calcium chloride ($CaCl_2$) at	**(1 %)**	**38.01**	**40.18**
	(2 %)	**42.14**	**44.31**
Citric acid (AsA) at	**(400 ppm)**	**38.09**	**40.26**
	(600 ppm)	**38.54**	**40.71**
Gibberellic acid (GA_3) at	**(50 ppm)**	**39.51**	**41.68**
	(100 ppm)	**43.02**	**45.19**
Salicylic acid (SA) at	**(400 ppm)**	**38.03**	**40.20**
	(600 ppm)	**39.01**	**41.18**

LSD at 0.05 %	**0.98**	**1.69**

The positive effect of antioxidants as ascorbic, citric and salicylic acids were participate in fruit development through their positive action on enhancing the biosynthesis of natural hormones, nutrient uptake, photosynthesis pigments and biosynthesis of sugars**(Rao et al., 2000)**, therefore antioxidants were used instead of auxins and other chemicals for enhancing growth and fruiting of various fruit trees, **(Ragab 2002)**, while salicylic acid (SA)was involved in regulating many processes regarding plant growth and development **(Asghari and Aghdam, 2010)**. Also, **(Abdelwahab, 2015)** reported that using antioxidants and /or salicylic acid led to a significant increase in fruit weight and yield of apricot fruits .

Fruit weight (g) and fruit size (cm^3).

Regarding the effect of antioxidants and other chemicals, the data in fig. (1) indicated that, GA_3at a concentration (100 ppm) caused the highest increase in fruit weight as compared with all treatments, meanwhile the control treatments gave the lowest values in fruit weight in both seasons. The addition of AsA at 600 ppm lead to a significant increase in fruit weight when compared with the application of SA, CiA and $CaCl_2$ in both seasons. The other treatment did not differ in their affecting for fruit weight in both seasons.Data in figure (2) indicated that the fruit size was in the same trend approximation in both studied seasons. The mentioned results agreed with the finding of **Ismail (2006)** on peach fruits, who found that the GA_3 treatments increased the average fruit weight. The increase in fruit weight by GA_3 treatments might be due the role of GA_3 in increasing the fruit cell elongation and expansion **(Abdelmoneim et al., 2007)**. Also, **Richard (2006)** reported that GA_3 promoted growth by increasing plasticity of the cell wall followed by the hydrolysis of starch into sugars, which reduces the cell water potential, resulting in the entry of water into the cell and causing elongation.**Abdelwahab (2015)** found that the spray SA on apricot trees led to a significant increase in fruit weight. The increases in fruit weight by only SA came from the positive effects of SA on increasing the bio-productivity as a result, increasing of photosynthesis pigments and photosynthesis process **(Champa et al., 2014)**.

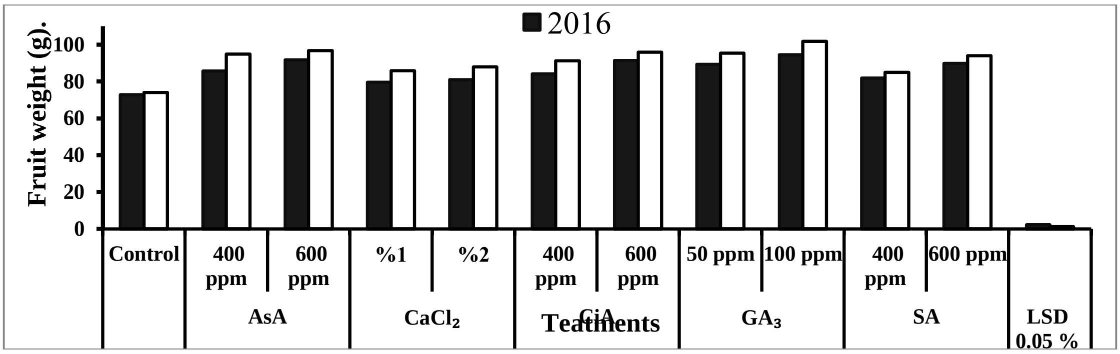

Fig.(1) Effect of some pre-harvest treatments on fruit weight (g) of Swelling peach trees during 2016 and 2017 seasons.

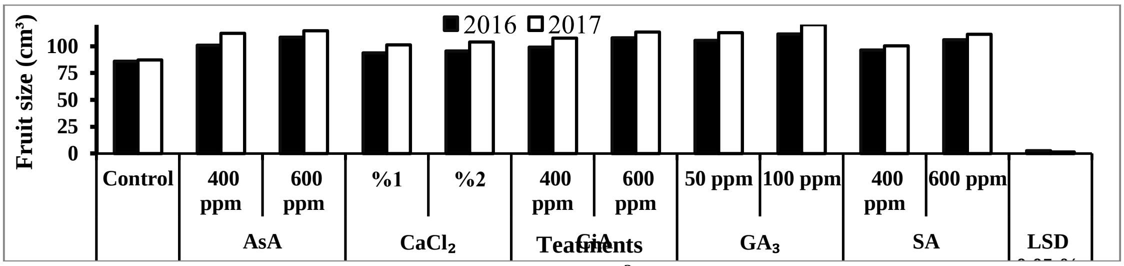

Fig.(2) Effect of some pre-harvest treatments on fruit size (cm^3) of Swelling peach trees during 2016 and 2017 seasons.

Fruit firmness (lb / inch^2).

Results obtained in fig. (3) indicated that GA_3at 50 and 100 ppm significantly increased fruit firmness as compared with all other treatments in both seasons. In addition, $CaCl_2$at 1&2 % and SA at 600 ppm had significantlycaused higher firmness than ascorbicand citric acids. Meanwhile, the lowest value of fruit firmness was obtained with trees untreated one. In this respect, **(Hassan et al., 2010)** on plum trees reported that GA_3 applications increased firmness of fruits. Moreover, **Samara et al., (2008)**on peach, who found that peach fruits possessed with calcium chloride retained maximum firmness. Also, **Elshazly et al.,(2013)** on peach fruits, who found that application of SA increased fruit firmness. Increasing fruit firmness as a result of GA_3 may be attributed to the role of GA_3 in decreasing the polygalacuronases and pectinmethylesterase activities, thus GA_3 treatments may maintain fruit firmness by their inhibitory effects on these enzymes, **Andrews and Li (1995).**

Furthermore, the increasing in fruit firmness as a result of calcium treatments may be due to that calcium ions interact with pectic polymers to form a cross-linked polymer network that increases mechanical strength, thus delaying senescence, **Glenn and Poovahiah (1986).** Also, **Tobias et al., (1993)** found that cell wall-bound $Ca^{2+}$is involved in maintaining cell wall integrity by binding carboxyl groups of polygalacturonate chains, which are mainly present in the middle lamella and primary cell wall. In addition, **Siddiqui and Bangerth(1995)** reported that the optimizing calcium content of fruit during growth and development is an important issue in order to slow their ripening and softening of fruit flesh by lowering respiration rates and reducing ethylene production. Finally, exogenous applied calcium, therefore stabilizes the plant cell wall and protects it from degrading enzymes, which have major influences on firmness.

Besides that, the increase in fruit firmness as a result of SA may be due to influence as a plant hormone in inhibiting ethylene biosynthesis and delaying fruit senescence, **Ozeker (2005)**. Also, it is reported that SA decreases the activities of major cell wall degrading enzyme; i.e. cellulase, polygalacuronase and xylanase,**Srivastava and Dwivedi, (2000).** Higher firmness in fruits treated with SA might be attributed the reduced hydrolysis of soluble starch, **(Muhammad et al., 2012)**.

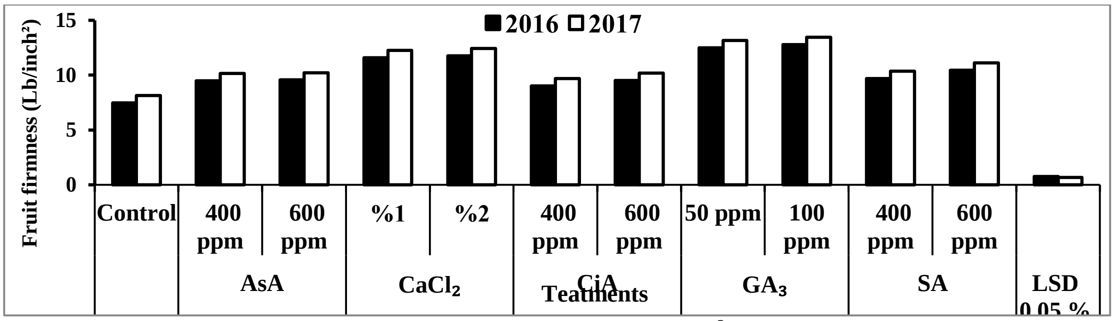

Fig.(3) Effect of some pre-harvest treatments on fruit firmness (lb/ inch^2)of Swelling peach trees during 2016 and 2017 seasons.

Total soluble solids percentage.

The data in table (2) indicated that foliar application by AsA and CiA at (600 ppm) gave the higher TSS % than the other treatments in both seasons, with insignificant differences between them, while the lowest value of the TSS % was obtained by GA_3 at 100 ppm followed by the control treatments. Moreover, the use of $CaCl_2$ at 1 % caused a marked increase in the TSS % as compared with GA_3 at 50 ppm and SA at 400 & 600 ppm in both seasons. These finding were confirmed with those obtained by **(Elbadawy, 2013)** on apricot, whofound that spraying ascorbic and citric acids improved fruit TSS content. **(Elshazly et al., 2013)**on peachwho foundapplication of GA_3 reduced TSS % fruits. The increase in total soluble solids as a result of ascorbic and citric acids sprayed may be due to their influence in increasing photosynthetic pigment which reflected on photosynthesis process and led to increase in carbohydrate content, **(Fayed 2010)**.Furthermore, the decrease in TSS% as a result of GA_3 treatments may be due to delay in fruit ripening caused by GA_3 treatment, **(Elshazly et al., 2013)**.

Total fruit acidity percentage(Malic acid).

he data in table(2) indicated a general trend of significantly increased of juice acidity as a result of the control and GA_3 at 100 ppm treatments ,while the AsA at 600 ppm gave the lowest in juice acidity as compared with other treatments in both seasons. However, application of $CaCl_2$ at 2 % gave the higher fruit acidity than spraying CiA at 400 ppm, AsA at 400 ppm in both seasons. The above findings were agreed with those obtained by **Hassan et al., (2010)** who reported that, application of GA_3 significantly increased titratable acidity of plum fruits.Furthermore, **(Tareen et al., 2012)**who found that peach fruits treated with SA significantly increased total acidity contents. Whereas, **(Elbadawy, 2013)** on apricot, whofound that spraying ascorbic and citric acids reduced total acidity. The reduction in juice acidity by ascorbic and citric acid treatments could be attributed to its influence on increasing the tissue respiration and increasing ripening associated activities. Also, the increasing acidity in calcium treated fruits might be due to reduction in metabolic changes of organic acid into carbon dioxide and water**, (Pila et al., 2010).**

TSS / Acid ratio.

Regarding to TSS/acid ratio the data in table (2) revealed that AsA at 400 & 600 ppm and CiA at 600 ppm increase fruit TSS/ acid ratio as compared with the other treatments. Moreover, spraying control and GA_3 at 100 ppmtreatments tended to decrease fruit TSS/ acid ratio in both studied seasons. Spraying $CaCl_2$ at 1 % caused increasing in TSS/ acid ratio as compared with that of GA_3 at 100 ppm in both seasons. The results were in harmony with those obtained by **Fayed (2010)** on, grapevine, who found that spraying ascorbic and citric acids increased TSS/ acid ratio.**(Elshazly et al., 2013)**who found that GA_3 decreased TSS/ acid ratio of peach fruits.

Total sugars percentage.

Data in table (2) indicated that AsA and CiA at (600 ppm) gave the higher total sugars than the other treatments in both studied seasons, while the lowest value of total sugars were obtained with GA_3 at 100 ppm followed by the control treatments. These findings were confirmed with those obtained by **Elshazly et al., (2013)** on peach fruits, who reported that spraying ascorbic and citric acids increased total sugars and the increase intotal sugars were may be due to that AsA and CiA had auxinic function and effective role in the biosynthesis of carbohydrates **(Ragab, 2002)**.

Table2. Effect of some preharvest treatments on TSS %, total acidity % (as malic acid), TSS/acid ratio and total sugars(%)of fruit Swelling peach during 2016 and 2017 seasons.

Characteristics		TSS %		Total acidity % (Malic acid)		TSS/acid ratio		Total sugars (%)	
Treatments	Seasons	2016	2017	2016	2017	2016	2017	2016	2017
Control		10.30	11.30	0.31	0.28	33.31	41.02	8.24	9.04
AsA	400ppm	12.28	13.15	0.16	0.14	75.60	91.85	10.19	10.96
	600ppm	12.54	13.39	0.15	0.12	85.19	109.25	10.45	11.16
$CaCl_2$	1%	12.23	13.05	0.19	0.16	63.31	79.98	10.23	10.88
	2%	11.98	12.67	0.22	0.19	55.14	65.57	9.99	10.56
CiA	400ppm	12.20	12.86	0.18	0.16	66.55	80.55	10.17	10.72
	600ppm	12.40	13.30	0.16	0.14	77.96	99.25	10.33	11.08
GA_3	50ppm	11.93	12.43	0.20	0.16	60.58	76.35	9.94	10.36
	100ppm	11.20	12.13	0.24	0.22	45.80	56.02	9.34	10.11
SA	400ppm	12.09	12.50	0.20	0.18	59.49	68.24	10.08	10.42
	600ppm	11.60	12.31	0.22	0.18	53.41	68.52	9.67	10.26
LSD 0.05 %		0.16	0.32	0.024	0.020	9.04	11.69	0.13	0.27

Fruit chlorophyll content(mg/100 g).

Data shown in table (3) indicated that trees treated with GA_3 at 100 ppm gave the highest values of chlorophyll a and b compared with the other treatments in both seasons. Meanwhile, the lowest value of chlorophyll b content was detected with trees received CiA at 600 ppm and control treatments in both seasons. The results were in line with those obtained by **(Ismail, 2006)**who found that, spraying of GA_3 led to increase in chlorophyll a and b content of peach fruits.

Anthocyanin content(mg/100 g).

Data in table **(3)** indicated that, generally CiA and AsA at 600 ppm significantly increased anthocyanin content, on the other hand, application of GA_3 at 50 & 100 ppm led to a significant reduction in anthocyanin content in peach fruits skin in both seasons as compared with the other treatments. In addition, CiA at 400 ppm increased the total anthocyanin content as compared with that of $CaCl_2$at 1&2 % and SA at 400 & 600 ppmin both seasons.

Table 3. Effect of some pre-harvest treatments on chlorophyll a& b content andanthocyanin(mg/100 g)of fruit Swelling peach during 2016 and 2017 seasons.

Characteristics		Chlorophyll a		Chlorophyll		Anthocya	
	Seasons	2016	2017	2016	2017	2016	201
Control		0.24	0.28	0.24	0.29	5.14	5.7
As	400ppm	0.27	0.31	0.27	0.28	6.27	6.3
A	600ppm	0.24	0.29	0.24	0.25	8.16	8.2
Cac	1%	0.25	0.30	0.26	0.30	5.17	5.3
l2	2%	0.26	0.31	0.25	0.27	6.06	6.2
Ci	400ppm	0.26	0.30	0.26	0.27	7.01	7.4
A	600ppm	0.25	0.29	0.23	0.25	8.89	8.9
GA	50ppm	0.29	0.31	0.35	0.37	2.33	2.4
3	100ppm	0.31	0.38	0.39	0.41	3.20	3.2
SA		0.26	0.31	0.26	0.29	4.68	4.9
	600ppm	0.28	0.33	0.28	0.33	5.55	5.9
LSD 0.05 %		0.041	0.065	0.030	0.018	0.16	0.1

The results are in harmony with those obtained by **(Ismail, 2006)** found that, spraying peach trees with GA_3 delayed anthocyanin accumulation and hence fruit ripening. Fruits of the control trees had the highest anthocyanin content as compared with SA at 400 ppm in both seasons. The increase in anthocyanin and decrease in chlorophyll a and b contents as a result of ascorbic and citric acid applications may be due to that these compounds enhanced the activity of chlorophylls enzymes which resulted in appearance of colored pigments,**(Farag and Nagy, 2012)**.Because carbohydrates are the main substrate for anthocyanin synthesis, AsA and CiA have a positive effect on carbohydrate biosynthesis **(Zulaikha 2013).**On the other contrary, it could be concluded that each of SA, GA_3 or $CaCl_2$ had the ability to delay peach fruit maturity and ripening since anthocyanin formation and its intensity are major attributes or criteria for these stages, **(Elshazly et al., 2013).**

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تأثير بعض معاملات ماقبل الحصاد على المحصول وجودة ثمارالخوخ سويلنج

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أجريت هذه الدراسة خلال موسمين متتاليين 2016 و2017 ,من أجل دراسة تأثير بعض معاملات ما قبل الحصاد مثل حمض الأسكوربيك,حمض الستريكوحمض السلسليكتركيز (400و600 جزء في المليون) , حمض الجبريليكتركيز (50 و 100 جزء في المليون)وكلوريد الكالسيوم تركيز (1 و 2٪ (وزن/حجم)) على المحصول و جودة ثمارالخوخ سولينج عمرها تسع سنوات,نامية في ارض رملية و تروى بالتنقيط.وأظهرت النتائج أن الرش بحمض الجبري ليكتركيز 100 جزء في المليون و كلوريد الكالسيومتركيز2٪ أعطى أعلى محصولا مقارنة مع باقى المعاملات الأخرى في كلا الموسمين. و ايضا أدت المعاملة بحمض الجبريليك تركيز 100 جزء في المليون الى زيادة معنوية فى وزن الثمرة وحجمها وصلابتها في كلا الموسمين. كما أدت المعاملة بكل من حمض الاسكوربيكوالستريكتركيز 600 جزء فى المليون الى زيادة محتوى الثمارمن الموادالصلبةالذائبة,السكريات الكلية و صبغة الأنثوسيانين فى قشرة الثمار، في حين أن كلا منحمض الأسكوربيكتركيز في 400و 600 جزء في المليون وحمض الستريك تركيز 600 جزء في المليون أدى الى زيادة النسبة المؤية TSS/acidللثمار, وفي نفس الوقت ادت المعاملة بحمض الجبريليكتركيز 100 جزء في المليون الى زيادة حموضة الثمار ومحتوي الثمار من الكلوروفيل أ و ب مقارنة بالمعاملات الأخرى في كلا الموسمين .بشكل عام ، يمكن الاستنتاج أن المعاملة بحمض الجبريليك و السلسليك وكلوريد الكالسيوم أدت الى زيادة ملحوظة فى المحصول و صلابة الثمار ومحتواها من الكلوروفيل أ و ب ,محتوى عالى من الموادالصلبة الذائبة والسكريات الكلية والانثوسيانين لثمار الخوخ صنف سويلنج مقارنة مع جميع المعاملات الأخرى.