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Effects of Plant Biostimulants and Forchlorfenuron on Fruit Set and Quality of "Canino" Apricot Fruits

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THIS experiment was carried out during 2019 and 2020 seasons on 6-yrs old of "Canino" apricot trees spaced at 6m × 4m apart and grown in sandy soil under drip irrigation system in a private farm at El-Nubaria region, Beheira governorate to investigate the effect of pre-harvest foliar spraying with salicylic acid at (25 and 50 ppm), seaweed extracts at (0.5g and 1g) and forchlorfenuron at (5ppm and 10ppm) at full bloom and at 10 days after fruit set on fruit set, fruit quality and yield of "Canino" apricot fruits. Results indicated that pre-harvest application of forchlorfenuron at full bloom and after 10 days of fruit set significantly increased fruit set, fruit size, weight and chlorophyll a and b. on the other hand, decreased peel carotene contents at harvest in comparison to control. The results also, reveal that, the application of the seaweed extracts enhanced fruit set and quality of apricots. Pre-harvest application of salicylic acid increased fruit weight, size and carotene. In summary, the results of the present study illustrated that pre-harvest application of salicylic acid, seaweeds and forchlorfenuron improved fruit set and fruit quality of apricot fruits especially at high concentrations.

Keywords: Apricot, Forchlorfenuron, Salicylic Acid, Plant Biostimulants, Fruit Set, Quality.

Introduction

Unfavorable conditions especially temperatures negatively affect fruit set, yield and fruit quality characteristics of apricot fruit trees. In such cases, pre-harvest application of plant bio-stimulants and plant growth regulators may enhance the quality and quantity of fruit yield by improving the natural mechanism of plant tolerance to stresses and repairing damage caused by stressful conditions **(**Calvo et al., 2014). Salicylic acid is an endogenous plant growth regulator that plays an essential role in plant growth and development, enhanced plant vigor under biotic and abiotic stresses, photosynthesis, transpiration and reduced fruit respiration (Klessig & Malamy, 1994 and Martínez-Esplá et al., 2017). Pre-harvest foliar spray of the cultivar "Flame Seedless" table grapes with salicylic acid improved fruit quality, produced less compact bunches, maintaining peel color, firmness, anthocyanins and phenols (Marzouk and Kassem, 2011). Seaweed extracts are an important source of major and minor nutrients, amino acids, vitamins, plant hormones, polysaccharides that contribute to improving plant growth, abiotic stresses tolerance, photosynthesis process, and enhancing yield and quality of several crops (Norrie and Keathley, 2006: Sharma et al., 2014 and Bulgari et al., 2019). Preharvest application of seaweeds enhanced fruit set and total yield of pear crop (Colavita et al., 2011). The plant growth regulator forchlorfenuron (N1-(2-chloro-4-pyridyl)-N3-phenylurea) is a synthetic cytokinin that enhanced cell division, increased cell size, increased fruit set, fruit weight, size and fruit yield and enhances the development of several fruiting crop species such as apples, apricots and grapes (Barngerth & Schröder, 1994 and Zabadal & Bukovac, 2006). Taha and El-Ghany (2016) found that preharvest treated apples with forchlorfenuron at (10ppm) increased fruit set, total yield and improved physical and chemical properties of "Anna" apple fruits. The purpose of this study was to evaluate the effects of plant biostimulants and forchlorfenuron on fruit set, yield and quality of "Canino" apricot fruits.

Materials and Methods

The present experiment was carried out during the two growing seasons 2019 and 2020, in a private orchard at EL-Nubaria region, Beheira

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governorate, Egypt on six-years-old "Canino" apricot trees budded on Balady rootstock grown in sandy soil. Trees were spaced at 6m× 4m apart and a drip irrigation system was adopted. The trials were designed as randomized completely block design (RCBD). The following seven treatments were obtained: Water only (control), salicylic acid at 50ppm, salicylic acid at 100ppm, seaweed extracts at 0.5g/l, seaweed at 1.0g/l, forchlorfenuron at 5ppm and forchlorfenuron at 10ppm. The treatments were sprayed at full bloom (19, 25 February during 2019 and 2020, respectively) and after fruit set with ten days (7, 10 March during 2019 and 2020, respectively). The trees were sprayed at the time corresponding to specific fruit growth stages established by monitoring the progress of the double sigmoid curve (Fig 1).

Four main branches representing all tree sides were chosen at random and labeled before spraying. After spraying the following data were measured as follows:

Fruit set percentage

The total number of flowers on each tagged limb was counted at full bloom. The number of set fruit was counted on the same limbs after one month from full bloom. Fruit set percentage was calculated according to (Westwood, 1993) as follows:

Fruit set % = Number of developing fruitlets / (Total number of flowers × 100)

Fruit Physical and chemical characteristics

At the harvest stage (29, 22 May during 2019 and 2020, respectively), ten fruits were randomly taken from each replicate in both seasons and the following characteristics were determined: Average fruit weight (g), fruit volume (cm^3). In addition, fruit length and fruit diameter (cm) were measured using a Mastercraft (electronic caliper with digital display) and fruit firmness was determined as (Ib/in^2) using Effigi pressure tester (mod. FT 011). The percentage of total soluble solids (TSS) was measured using a hand refractometer, acidity as malic acid was determined according to (A.O.A.C., 1985) and maturation index defined as TSS/ acidity ratio was estimated. Total sugars were determined by using the phenol sulfuric acid method (Smith, 1956). Chlorophyll a, b and beta-carotene in the fruit peel were determined according to (Lichtenthaler and Wellburn, 1985).

Experimental design and statistical analysis

In the field, treatments were arranged as a randomized complete block design (RCBD). The obtained data were analyzed using Statistical Analysis System (SAS, 2000). The Least Significant Differences (LSD) at 0.05 levels according to Sendecor and Cochran (1980) were used to separate treatments means.

Results and Discussion

The data presented in Fig. 2 indicated that pre-harvest application of different treatments

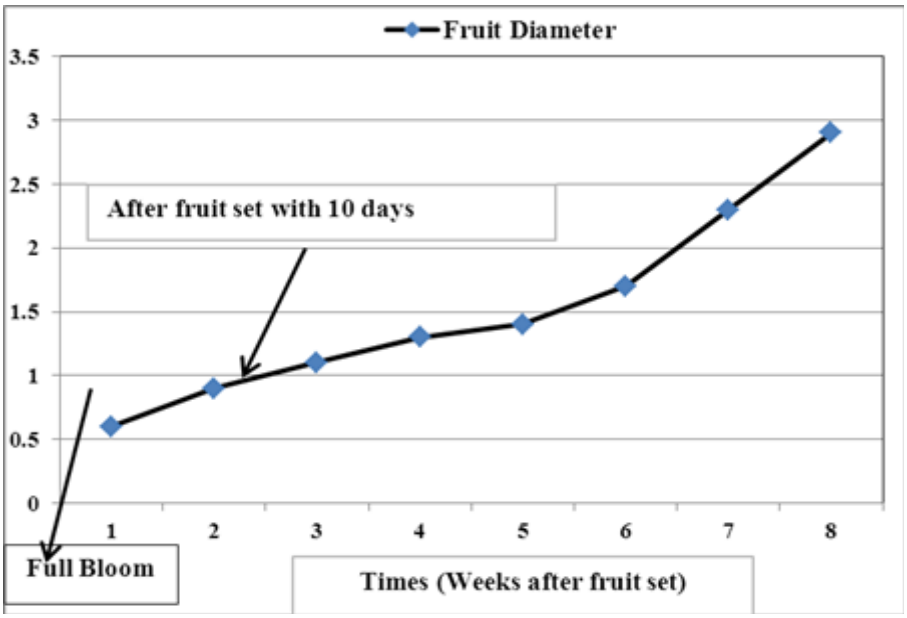

Fig. 1. Double sigmoidal curve of "Canino" apricot fruits.

significantly enhanced fruit set percentage as compared with control. The maximum fruit set (75.6 and 68.6%) was recorded by forchlorfenuron at 10ppm followed by seaweed extract at 1g/ L in a consistent manner during 2019 ad 2020 seasons. The aforementioned data agreed with the reported results of Assad (2013) on plums, Taha et al. (2019) on apricot and Guirguis et al. (2003) on pear.

The data in Table 1 showed that the best result of fruit weight was obtained with forchlorfenuron at 10ppm (24.47 and 26.56), forchlorfenuron at 5ppm (23.24 and 25.92) and seaweed at 1g/L (23.25 and 24.9). On the other hand, the lowest fruit weight was consistently obtained by control in both seasons of study.

The data in Table 1 indicated that, preharvest spray of forchlorfenuron achieved the highest significant average of fruit flesh weight followed by seaweed and salicylic acid biostimulants as compared with control. The highest value was obtained by forchlorfenuron at 10ppm and the lowest value was obtained by control. A similar trend of results was obtained for stone weight in both seasons of study. Such findings were in line with (Guirguis et al., 2003, Calvo et al., 2014 and Champa et al., 2015).

The data in Table 2 showed that preharvest application of seaweed extract at 1g and forchlorfenuron at 10ppm gave the highest fruit size and diameter consistently in both seasons

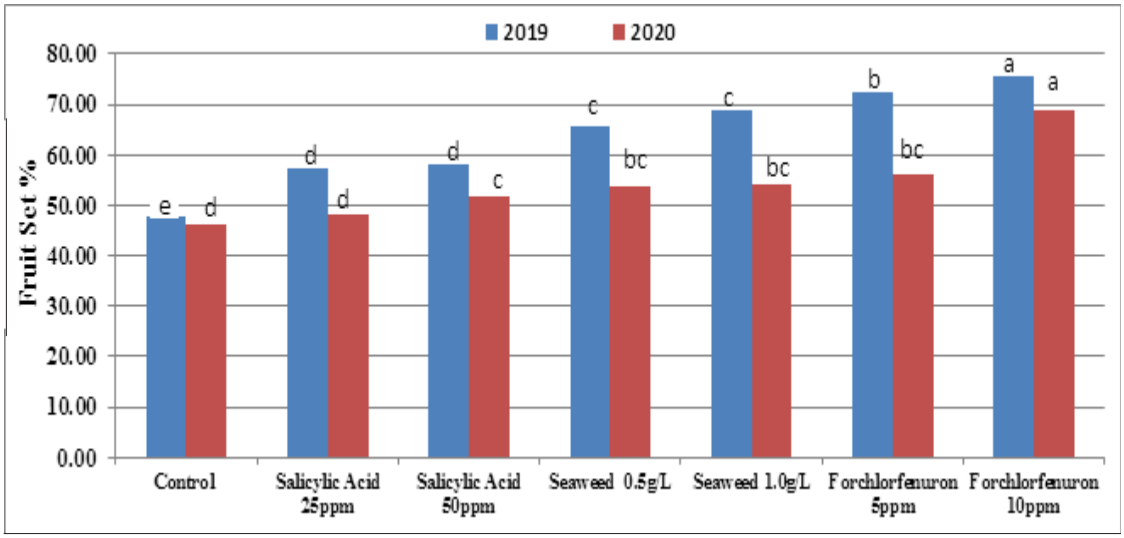

Fig.2. Effect of salicylic acid, seaweed extract and forchlorfenuron on fruit set of "Canino" apricot fruits during 2019 and 2020 seasons.

TABLE 1. Effect of salicylic acid, seaweed extract and forchlorfenuron on fruit weight, stone weight and flesh weight of "Canino" apricot fruits during 2019 and 2020 seasons.

Treatments	Fruit Weight (g)		Stone Weight (g)		Flesh Weight (g)	
	2019	2020	2019	2020	2019	2020
Control	17.40f	17.79g	1.77g	1.77g	15.63f	16.02g
Salicylic Acid 25ppm	18.09e	18.35f	1.82f	1.81f	16.28e	16.54f
Salicylic Acid 50ppm	19.29d	20.03e	1.85e	1.83e	17.44d	18.2e
Seaweed 0.5g/L	20.39c	21.29d	2.01d	2.06d	18.38c	19.23d
Seaweed 1.0g/L	23.25b	24.90c	2.23c	2.23c	21.02b	22.68c
Forchlorfenuron 5ppm	23.24b	25.92b	2.35b	2.38b	21.07b	23.54b
Forchlorfenuron 10ppm	24.47a	26.56a	2.41a	2.46a	22.06a	24.10a

Means within columns with the same letter are not significantly different using the least significant difference (LSD) at $P \leq 0.05$ levels.

of study as compared with control. Moreover, forchlorfenuron at 5ppm and seaweed at 0.5g/L gave the same effect on the mentioned characteristics.

The data in Table 2 indicated that forchlorfenuron at 10ppm, forchlorfenuron at 5ppm, seaweed at 0.5g/ L and salicylic acid at 50ppm significantly increased fruit firmness as compared with control. The highest value was obtained by forchlorfenuron at 10ppm (9.2 and 9.4) and the lowest value was obtained by control (8.93 and 8.5). The above findings agreed with those found by (Norrie and Kealthy, 2006; Champa et al., 2015 and Taha and Elghany, 2016**)**.

The data in Table 3 revealed that forchlorfenuron at 10 and 5 ppm, seaweed at 0.5 and 1g/ L induced higher TSS in the 2019 and 2020 seasons. On the other hand, there was no significant difference was obtained by salicylic acid at 50 and 100ppm especially at the second season as compared with the control.

Salicylic acid and seaweed extract showed the lowest fruit acidity as compared with forchlorfenuron treatment. Moreover, the pre-harvest spray of forchlorfenuron at full bloom and after two weeks of fruit set gave the highest value of fruit acidity as compared with control.

TABLE 2. Effect of salicylic acid, seaweed extract and forchlorfenuron on fruit size, fruit diameter and firmness of "Canino" apricot fruits during 2019 and 2020 seasons.

Treatments	Fruit size (mm)		Fruit diameter (cm^3)		Firmness (kg/cm^3)	
	2019	2020	2019	2020	2019	2020
Control	19.94e	20.64e	3.07e	3.17e	8.43d	8.50f
Salicylic Acid 25ppm	20.66d	21.36d	3.23d	3.30d	8.63c	8.73e
Salicylic Acid 50ppm	22.50c	23.41c	3.33c	3.37cd	8.90b	8.97d
Seaweed 0.5g/L	24.25b	25.26b	3.37c	3.40c	9.10a	9.20c
Seaweed 1.0g/L	25.13a	26.03a	3.53b	3.53b	8.73c	9.00d
Forchlorfenuron 5ppm	24.12b	25.42b	3.37c	3.43c	9.10a	9.30b
Forchlorfenuron 10ppm	25.42a	26.21a	3.63a	3.63a	9.20a	9.40a

Means within columns with the same letter are not significantly different using the least significant difference (LSD) at $P \leq 0.05$ levels.

TABLE 3. Effect of salicylic acid, seaweed extract and forchlorfenuron on TSS %, Acidity and Total sugars % of "Canino" apricot fruits during 2019 and 2020 seasons.

Treatments	TSS %		Acidity %		Total sugars %	
	2019	2020	2019	2020	2019	2020
Control	12.60f	12.40d	0.83de	0.813b	10.00c	10.00e
Salicylic Acid 25ppm	12.90e	12.50d	0.83de	0.810b	10.33bc	10.33de
Salicylic Acid 50ppm	13.10cd	12.60d	0.84c	0.800b	10.33bc	10.67cd
Seaweed 0.5g/L	13.00de	12.90c	0.84cd	0.813b	10.50b	11.00c
Seaweed 1.0g/L	13.20bc	12.90c	0.84cd	0.810b	11.00a	11.00c
Forchlorfenuron 5ppm	13.30b	13.20b	0.87b	0.86a	11.17a	11.50b
Forchlorfenuron 10ppm	13.50a	13.70a	0.90a	0.873a	11.33a	12.33a

Means within columns with the same letter are not significantly different using the least significant difference (LSD) at $P \leq 0.05$ levels.

According to the data in Table 3, the application of forchlorfenuron at 5 and 10ppm induced higher total sugars in the 2019 and 2020 seasons as compared with control and other treatments. The results of the present_study are in harmony with those obtained by (Greene, 1989 and Taha et al., 2019**)**.

Data in Table 4 indicated that all preharvest treatments significantly induced higher chlorophyll a content in the fruit peel of treated-trees as compared with control in both seasons. The highest value was obtained by forchlorfenuron at 10ppm (3.87 and 4.03) and the lowest value was obtained by control (3.52 and 3.58). On the other hand, a similar trend of results was obtained for chlorophyll b.

The data in Table 4 showed that the lowest carotene content in the peel of apricot fruits was obtained by forchlorfenuron and seaweed treatments and the highest carotene contents were obtained by salicylic acid treatments especially at 100ppm as compared by control in both seasons 2019 and 2020. Such findings were in line with (Taha & Elghany, 2016, Martinez-Espla et al., 2017 and Taha et al., 2019).

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TABLE 4. Effect of salicylic acid, seaweed extract and forchlorfenuron on Chlorophyll a, Cholorophyll b and Carotene of "Canino" apricot fruit peel during 2019 and 2020 seasons.

Treatments	Chlorophyll a (mg/100g)		Chlorophyll b (mg/100g)		Carotene (mg/100g)	
	2019	2020	2019	2020	2019	2020
Control	3.52c	3.58c	1.70c	1.78b	1.25c	1.21b
Salicylic Acid 25ppm	3.18e	3.17d	1.62d	1.65bc	1.33b	1.35a
Salicylic Acid 50ppm	3.18e	3.16d	1.59d	1.57c	1.36a	1.39a
Seaweed 0.5g/L	3.49d	3.56c	1.62d	1.82ab	1.32b	1.26b
Seaweed 1.0g/L	3.53c	3.57c	1.59d	1.82ab	1.33b	1.26b
Forchlorfenuron 5ppm	3.81b	3.91b	1.94b	1.82ab	1.03d	1.07c
Forchlorfenuron 10ppm	3.87a	4.03a	2.03a	2.01a	1.00e	0.997c

Means within columns with the same letter are not significantly different using the least significant difference (LSD) at $P \leq 0.05$ levels.

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تأثير المحفزات النباتية وفوركلورفينيرون على العقد، وجودة ثمار المشمش صنف "كانينو"

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أجريت هذه الدراسة بغرض بحث تأثير معاملات ما قبل الجمع بحمض السالسيليك بتركيز ٢٥، ٥٠ جزء فى المليون ومستخلص الطحالب بتركيز ٠,٥ جم، ١ جم/لتر و فوركلورفنيرون بتركيز ٥، ١٠ جزء فى المليون علي العقد وجودة ثمار المشمش صنف كانينو. وأوضحت النتائج الي أن المعاملة بالفوركلورفنيرون أثناء مرحلة الأزهار الكامل وبعد مرور ١٠ أيام علي العقد أدت الي زيادة معنوية فى نسبة العقد وحجم الثمار ووزنها ومحتواها من كلوروفيل أ، ب، بينما أدت الي نقص محتوي الكاروتين بالقشرة مقارنة بالكنترول. كما أدت المعاملة بمستخلص الطحالب البحرية الي تحسين نسبة عقد الثمار وجودتها وخاصة وزن الثمار وقطرها. بينما أدت المعاملة بحامض السالسيليك الي زيادة حجم الثمار ووزنها ومحتواها من الكاروتين.

الكلمات الدالة: المشمش - فوركلورفينيرون - حامض السالسيليك - المحفزات النباتية - جودة الثمار.