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Impact of Herosten at Different Concentrations on Productivity and Fruit Quality of Williams Banana

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Abstract

The present investigation was conducted on an experimental farm at the El-Kanater Horticultural Research Station in Qayubeia Governorate, Egypt during the 2018 and 2019 experimental seasons. The banana Williams cultivar were plant materials for this research, grown in clay loamy soil and the mates (plantation holes) were 3×4 meters apart under the flood irrigation system. Anyhow, Herosten the commercial name was the source of auxin used in this investigation. This compound contains (1.5 % NAA; 1.5 NAD and 1.5 % NAO), sprinkles were added sprinkles monthly five times during the period from first July to first November at a rate of 0.25, 0.375, 0.50 and 0.625 g per liter. Taking into consideration that sprays treatments were applied covering the whole bunch of each plant, whereas 0.5 liters was found to be sufficient in this concern to study the effect of different concentrations of Herosten sprays on productivity and fruit quality of Williams banana plants. Definitively, it can be shown from the results obtained that, spraying of Williams banana plants grown under similar environmental conditions and horticulture practices adopted in the current experiment with Herosten (auxin) at 0.375 g per liter and/or Herosten (auxin) at 0.50 g per liter is a beneficial method for enhancing production and fruit quality. In comparison, the lowest values of most of the parameters under investigation were typically associated with the control (water spray).

Keywords: Williams banana, Herosten, Auxin, Foliar spray, Productivity, bunch and Fruit Quality.

Introduction

Banana (*Musa sp.*) is the dominant crop in the tropical and subtropical parts of the world. In Egypt, it is the most popular fruit crop after citrus and grapes. It occupies an area of 68800.8 feddans with a production area of 1228458 tons in **2017 (FAO STAT).** Williams is one of the most commonly cultivated banana varieties in the world (**Xu *et al.*, 2005 and FAO, 2018**). In Egypt, it is successfully grown in freshly reclaimed soils for its excellent results; large bunches with longer fingers, excellent taste and high transport tolerance (**Barakat *et al.*, 2011**). Williams banana is excellent since it has a big bunch of long fingers and an excellent flavor. Due to its large size and fast growth rate, a relatively large amount of nutrients is needed to sustain the high production of good quality fruit (**Saleh, 1996**).

NAA is a synthetic auxin plant hormone that is routinely used for the vegetative spread of stem and cutting plants. The effect of NAA on plant growth depends heavily on the time of entry and concentration. NAA has been shown to dramatically improve the formation of cellulose fiber in plants. In most fruit plants, the fruit drop is managed by spraying NAA in various fruit crops at different concentrations. It is applied after blossom fertilization. **Harhash and Al-Obeed (2007)** the application of 150 ppm NAA increased yield and improved fruit quality of Barhee and Shahi cultivar. Besides, **Nawaz *et al.*, (2008)** analyzed the effect of NAA foliar spray at 10, 15 and 20 ppm in Kinnow mandarin and overall vitamin C content (45, 30 mg/100g) in 15 ppm NAA. However, **Iqbal *et al.*, (2009)** applied 15, 30, 45, 60, 75 and 90 ppm NAA by foliar spray and reported that 45 ppm of spray reduced pre-harvest fruit decline, increased yield, pulp/acid ratio, TSS, total sugar, acidity and ascorbic acid in guava.

Thus, the goal of this study was to elucidate the effect of different concentrations of Herosten (1.5 % NAA, 1.5% NAD and 1.5 % NAO) sprays on the productivity and fruit quality of Williams banana plants.

Materials and Methods

The present investigation was carried out in an experimental farm at the El-Kanater Horticultural Research Station in Qayubeia Governorate, Egypt during the 2018 and 2019 experimental seasons. Banana Williams cultivar was the plant materials devoted for this study, grown in clay loamy soil and mates (plantation holes) were 3×4 meters apart under a flood irrigation system. Before the experiment had been conducted in 1st season, mechanical and chemical analysis of the experimental soil surface (0–30 cm depth) was determined according to methods described by **Piper, (1950)** and **Jackson, (1973)** as shown in **Table (1).**

Table 1. Mechanical and chemical analyses of experimental orchard soil 0- 30 cm depth in the 2018 season.

A- Physical analysis						
Sand (%)	**Silt (%)**	**Clay (%)**	**Soil texture**	**F.C. (%)**	**W.P. (%)**	**A.W. (%)**
16.5	30.3	53.2	Clay loamy	42.5	21.2	20.1

B- Chemical analysis										
	Available nutrients (mg/kg)							E.C. ds/m	pH (1: 2.5)	$CaCO_3$
	N	P	K	Fe	Zn	Mn	Cu			
Total	665	340	442.5	313.6	113	146	47	3.71	7.8	3.6
Avail.	63	13.7	61.2	21.1	5.7	16.6	2.6			

Chemical NPK Fertilizers (RD):

One rate of chemical fertilizers NPK was employed in this study. 100 % of chemical NPK from ammonium nitrate 33.5% N, superphosphate 15.5 % P_2O_5 and potassium sulphate 48% (K_2O) equal (2.68; 0.70 and 2.0 kg/plant), respectively. **Ibrahim (2003)**.

Herosten (source of auxin):

Herosten the commercial name source was of auxin which was used in this investigation. This compound contains (1.5 % NAA; 1.5 NAD and 1.5 % NAO) was added to sprinkles monthly six times during the period from first July to first December at rates of 0.25, 0.375, 0.50 and 0.625 g per liter. Taking into consideration those spray treatments were applied covering the whole bunch of each plant, whereas 0.5 liters was found to be sufficient in this concern.

The experiment consisted of five treatments as follows:

1- T1: Control (water sprayed).
2- T2: Herosten at 0.25 g per liter**.**
3- T3: Herosten at 0.375 g per liter.
4- T4: Herosten at 0.50 g per liter.
5- T5: Herosten at 0.625 g per liter.

Experimental layout:

The complete randomized block design was used for arranging the differential investigated treatments with three replications whereas, each replicate was represented by four stools with 3 similar plants (ratoons) left per each for cropping in the current season and following one. The selected stools (mats) required for this experiment were equally classified according to their vigor into 3 categories, whereas plants of each class were similarly subjected to their own investigated treatments.

1. Time from bunch shooting to harvesting:

Duration needed from bunch shooting till harvesting (maturation) in days was also recorded.

2. Life cycle:

Duration extended from sucker emergence till harvesting (maturation) in days was also calculated.

3. Yield parameters:

Bunch length; bunch circumference (cm); bunch weight (kg); the number of hands/bunch; the number of fingers/hand; and the number of fingers/bunch; were determined as yield parameters. As well, the yield was calculated according to the following equations for both seasons:

$$\text{Yield (ton/fed.)} = \frac{\text{Bunch weight (kg) x number of the plant (1050 plants) fed.}}{1000}$$

4. Fruit quality:

Samples each of two hands from the middle portion of every bunch were ripened by wrapping with the newspaper in closed polyethylene bags and kept at room temperature until reaching the ripe stage of yellow flecked with brown. After ripening, the following fruit physical and chemical characteristics were determined:

4.1. Fruit physical characteristics:

4.1.1. Finger length (cm): By measuring the length of the finger with the pedicel.

4.1.2. Finger diameter (cm): By measuring the middle part of the finger using a vernier-caliper.

4.1.3. Finger weight: It was done by weighing all fingers of each hand then the average weight of each finger/fruit in (g) was calculated.

4.1.4. Finger pulp, peel weight (g) and pulp/peel ratio: Fresh pulp and peel weight in (g), as well as pulp/peel ratio of the finger, were determined.

4.1.5. Pulp and peel percentages: pulp and peel percentages of the finger were calculated.

4.2. Fruit chemical properties:

4.2.1. Total soluble solids (TSS):

Carl Zeiss's hand refractometer was used to determine the total soluble solids percentage in the pulp.

4.2.2. Total titratable acidity:

Total titratable acidity was determined and calculated as grams of malic acid in 100 grams of fresh pulp by titration with a 0.1 N NaOH solution using phenolphthalein indicator according to the method described by **A.O.A.C (2000).**

4.2.3. Total soluble solids content/acid ratio: TSS/acid ratio was estimated from results recorded of fruit juice TSS and total acidity by dividing TSS% over total acidity.

4.2.4. Total sugars and reducing sugars: Percentage of both total sugars and reducing sugars in the fresh pulp of ripened fruits were determined colorimetrically according to **Dubois *et al.*, (1956)**.

4.2.5. Total carbohydrates and starch: Total carbohydrates and starch (%) in the fresh pulp of fruits were determined colorimetrically according to **Smith *et al.*, (1956)**.

Statistical Analysis:

All data obtained during both seasons of the study were subjected to analysis of variances according to **Snedecor and Cochram, (1980)** and significant differences among means were determined according to Duncan's multiple test range **Duncan, (1955).**

Results and Discussion

Time to harvesting (days) and Life cycle (days):

Regarding the response of time to harvesting and life cycle (days) of "Williams" banana plants to the different rates sprayed treatments with Herosten in this investigation, data in **Table (2)** displayed obviously that, time to the harvesting and life cycle of plants was decreased by increasing the rate Herosten during both seasons of study. In this respect manner, T5 (Herosten at 0.625 g per liter) followed by T4 (Herosten at 0.50 g per liter) gave the shortest period to harvesting in both 2018 and 2019 experimental seasons, respectively.

Table 2. Effect of Herosten on Time to harvesting (days) and life cycle (days) of Williams banana plants during 2018 and 2019 experimental seasons.

Parameters / Treatments	Time to harvesting (days)		Life cycle (days)	
	2018	2019	2018	2019
T1: Control (Water spared)	122.7 a	125.3 a	524.3 a	529.3 a
T2: Herosten at 0.25 g per liter**.**	116.7 bc	125.3 a	524.3 a	526.0 a
T3: Herosten at 0.375 g per liter.	115.0 c	118.3 b	486.0 a	490.7 c
T4: Herosten at 0.50 g per liter.	119.3 b	125.0 a	510.0 a	518.0 b
T5: Herosten at 0.625 g per liter.	111.0 d	114.3 c	455.7 a	494.3 c

Means followed by the same letter/s within each column didn't significantly differ at 5% level.

Bunch length (cm) and bunch circumference (cm):

Regarding the response of bunch length (cm) of "Williams" banana plants to the different rates sprayed treatments with Herosten in this investigation, data in **Table (3)** displayed obviously that, the tallest bunch was always concomitant to such plants sprayed with tap water (control) treatment during both seasons. The abovementioned treatment (control) was superior in both seasons. On the other hand, the reverse trend was true with those banana plants sprayed at the rate of (0.375 g/l) which induced the shortest bunch from the standpoint of statistics throughout the 2018 and 2019 seasons of study. Moreover, other sprayed treatments of Herosten i.e., (0.250, 0.625 and 0.500g/l) ranked statistically second, third and fourth in the two seasons. Moreover, it is quite evident as shown from tabulated data in Table (2) that the response of bunch circumference (cm) followed nearly the same trend previously discussed with bunch length (cm).

Table 3. Effect of Herosten on bunch length (cm) and bunch circumference (cm) of Williams banana plants during 2018 and 2019 experimental seasons.

Parameters / Treatments	Bunch length (cm)		Bunch circumference (cm)	
	2018	2019	2018	2019
T1: Control (Water spared)	112.53 a	118.60 a	108.30 c	114.20 c
T2: Herosten at 0.25 g per liter**.**	108.82 b	113.40 b	112.17 a	118.60 a
T3: Herosten at 0.375 g per liter.	94.47 e	99.20 e	98.77 e	102.50 e
T4: Herosten at 0.50 g per liter.	102.50 d	104.50 d	106.23 d	108.30 d
T5: Herosten at 0.625 g per liter.	106.17 c	110.30 c	109.40 b	114.90 b

Means followed by the same letter/s within each column didn't significantly differ at 5% level.

Bunch weight (kg) and yield (kg):

It is evident from data obtained during both the 2018 and 2019 seasons and tabulated in **Table (4)** that the bunch weight and yield (kg) of "Williams" banana plants responded obviously to the different spraying treatments with Herosten at various rates. However, the heaviest bunch weight and yield (kg) were always significantly in relationship with those banana holes sprayed with Herosten at (0.375 g/l) during both seasons of study. Moreover, banana plants sprayed with both treatments of Herosten at rates (0.625 and 0.250 g/l) ranked statistically the second then followed by the treatment of (0.500 g/l) which ranked third from the standpoint of statistic. In addition to that, the control plants of "Williams" banana cv., that sprayed with tap water (0.0 g/l of Herosten/ control) was statistically inferior as exhibited the least value and the lightest bunch weight and yield (kg). Such a trend was detected during both the first and second seasons of study.

Table 4. Effect of Herosten on bunch weight (kg) and yield (ton/fed.) of Williams banana plants during 2018 and 2019 experimental seasons**.**

Parameters / Treatments	Bunch weight (kg)		Yield (ton/fed)	
	2018	**2019**	**2018**	**2019**
T1: Control (Water spared)	27.91 d	27.37 d	29.31 d	28.74 d
T2: Herosten at 0.25 g per liter**.**	30.75 b	33.25 ab	32.29 b	34.91 ab
T3: Herosten at 0.375 g per liter.	32.45 a	33.64 a	34.07 a	35.32 a
T4: Herosten at 0.50 g per liter.	29.24 c	31.50 c	30.70 c	28.74 d
T5: Herosten at 0.625 g per liter.	31.10 b	32.85 b	32.66 b	34.49 b

Means followed by the same letter/s within each column didn't significantly differ at 5% level.

Number of hands per bunch; the number of fingers/hand and total No. of fingers/bunch:

Concerning the number of hands per bunch in response to the effect of Herosten foliar sprayed rates; data in **Table (5)** showed clearly that, spraying banana plants with Herosten at rates (0.625, 0.375 & 0.500 g/l) during both seasons and rate of (0.0 g/l/ control) in the first season only resulted from an increase significantly in the No. of hands per bunch over that of both (control) and rate of (0.250 g/l) in the first or second season respectively. On the other hand, plants sprayed with Herosten at the rate of (0.250 g/l) in the second were statistically the inferior treatment which induced significantly the least No. of hands per bunch.

Referring to the effect of the various rates of Herosten in foliar spray solutions on "Willimas" banana cv., productivity estimated as either No. of fingers/hand data responded in **Table (5)** declared that, the highest values of No. of fingers per hand were significantly inclosed relationship to those banana plants sprayed with all treatments under study during both seasons except with both rates of (0.0 g/l control) and (0.250 g/l) in the second season only, whereas both abovementioned treatments were less effective from the standpoint of statistic in this respect.

Concerning the response of total No. of fingers per bunch of banana "Williams" to the different rates of Herosten in foliar spray solutions, data in Table (5) displayed obviously that, the response typically followed the same trend previously detected with the No. of fingers/hand. Moreover, the greatest and the highest total No. of fingers per bunch were always concomitant to the rates of (0.625, 0.375, 0.500 g/l) during seasons and (0.0 g/l/control) in the first season only. Whereas, differences between the abovementioned treatments did not reach the level of significance. On the other hand, the reverse trend was true both treatment of the control in the second season and spraying with the rate of (0.250 g/l) in both seasons of study which had significantly the least total No. of fingers/bunch.

Table 5. Effect of Herosten on No. of hands/bunch, No. of fingers/hand and total No. of fingers/bunch of Williams banana plants during 2018 and 2019 experimental seasons

Parameters / Treatments	No. of hands/ bunch		No. of fingers/ hand		Total No. of fingers /bunch	
	2018	**2019**	**2018**	**2019**	**2018**	**2019**
T1: Control (Water spared)	13.00 ab	12.33 bc	13.67a	13.00b	177.7ab	160.3b
T2: Herosten at 0.25 g per liter**.**	11.00 b	11.33 c	13.33a	13.00b	146.7b	147.3b
T3: Herosten at 0.375 g per liter.	13.00 ab	13.67 ab	16.00a	16.00a	207.3a	219.0a
T4: Herosten at 0.50 g per liter.	13.33 ab	13.33 a-c	13.33a	13.67ab	177.3ab	182.0ab
T5: Herosten at 0.625 g per liter.	14.67 a	15.00 a	15.00a	15.00ab	220.3a	224.7a

Means followed by the same letter/s within each column didn't significantly differ at 5% level.

Fruit quality:

1- Physical characteristics:

1-a. Finger length (cm):

Regarding the response of the finger length (cm) of "Williams" banana cv., to the different levels of sprayed Herosten treatments, data represented in **Table (6)** displayed that, banana plants sprayed with Herosten at the rate (0.375 g/l) induced statistically the tallest finger length i.e., (18.70 & 19.23 cm) during the first and second seasons of study, respectively. Followed in statistically a descending order by treatments of (control, 0.625 g/l and 0.250 g/l) in the first season whereas treatment of (0.625 g/l) in the second season only, ranked second but differences between them did not reach the level of significance. Moreover, banana plants sprayed with Herosten treatment at the rate of (0.50 g/l) were statistically inferior as exhibited the least values and the shortest finger length (cm.) during both the 2018 and 2019 seasons of study.

1-b. Finger diameter (cm):

Concerning the effect of the different Herosten treatments sprayed rates on the finger diameter (cm) of banana, data obtained in **Table (6)** displayed clearly that, fingers diameter (cm) slightly responded, whereas differences in all cases were not significant and could be safely neglected especially in the first season of study when all sprayed treatments were compared each other. However, in the second one, variance in diameter of "Williams" banana fingers was so slight between the investigated treatments to be significant, since the differences didn`t reach the level of significance in the second season except with treatment at the rate (0.525 g/l) which was the inferior as exhibited the least significant value of fingers diameter in the second season of study.

Table 6. Effect of Herosten on finger length (cm) and finger diameter (cm) of Williams banana plants during 2018 and 2019 experimental seasons.

Parameters	Finger length (cm)		Finger diameter (cm)	
Treatments	2018	2019	2018	2019
T1: Control (Water spared)	18.10 ab	17.90 b	3.58 a	3.66 ab
T2: Herosten at 0.25 g per liter**.**	17.90 ab	17.80 b	3.42 a	3.70 ab
T3: Herosten at 0.375 g per liter.	18.70 a	19.23 a	3.74 a	3.92 a
T4: Herosten at 0.50 g per liter.	16.90 b	16.70 c	3.31 a	3.42 b
T5: Herosten at 0.625 g per liter.	18.30 ab	18.50 ab	3.62 a	3.74 ab

Means followed by the same letter/s within each column didn’t significantly differ at 5% level.

1-c. Fruit (finger) weight (g):

Regarding the average finger weight as influenced by the Herosten (auxin) foliar spray solution at different four rates i.e., (0.250, 0.375, 0.500 and 0.625 gm/liter), Data obtained in **Table (7)** revealed obviously that, a considerable variance during both seasons of study. However, the heaviest weight of fingers was always in closed relationship to banana plants (fingers sprayed with the highest rate of Herosten (0.625 gm/l) in both seasons and the control treatment (sprayed plants with tap water) in the first season only. Contrary to that, plants sprayed with Herosten at the rate (0.500 gm/l) induced significantly the lightest weight of fruits (fingers) during both seasons of study.

1-d. Pulp weight per finger estimated as (g or %):

Referring to the pulp weight of Williams banana fruits (fingers) as affected by the abovementioned treatments, data in **Table (7)** indicated clearly that, the positive relationship between the fourth treatment (plants sprayed with Herosten at (0.500 g/l). Since the heaviest pulp weight expressed either as (grams) or (percent) was significantly exhibited with the fourth treatment sprayed plants. On the other hand, an opposite trend was observed with those banana plants sprayed with the least rate of Herosten (0.250 g/l) which always significantly induced the lightest and the least values of pulp weight per finger estimated either as (gm. or %) during both seasons of study. In addition to that, other treatments of Herosten (T1/control, T3 and T5) induced pulp were statistically in between the abovementioned two extents as their effect on average pulp weight either as grams and percent. Such trends were detected during both the 2018 and 2019 seasons of study.

Table 7. The response of (fruit weight and pulp weight as gms or percentages) of "Williams" banana cultivar to the different rates of Herosten spray solutions during the 2018 and 2019 seasons**.**

Parameters	Finger weight (g)		Pulp			
			Weight (g)		Percentages (%)	
Treatments	2018	2019	2018	2019	2018	2019
T1: Control (Water spared)	112.70 a	115.30 b	67.97 b	73.86 b	60.31 b	64.06 c
T2: Herosten at 0.25 g per liter.	98.90 c	107.55 d	61.17 d	62.92 e	61.85 b	58.50 d
T3: Herosten at 0.375 g per liter.	102.40 b	109.40 c	69.50 b	70.97 c	67.89 b	64.87 b
T4: Herosten at 0.50 g per liter.	94.30 d	96.67 e	82.50 a	83.92 a	87.49 a	86.81 a
T5: Herosten at 0.625 g per liter.	112.10 a	116.90 a	63.78 c	63.83 d	62.90 b	54.61 e

Means followed by the same letter/s within each column didn’t significantly differ at 5% level.

1-e. Peel weight per finger expressed as (g or %):

Obtained data presented in **Table (8)** declared that, peel weight/ finger estimated as grams or percentage of Williams banana plant cultivar followed typically the same two trends previously detected with finger weight (g.) regarding the effect of either (T5) or (T4). In other words, it could be mentioned that banana plants sprayed with the highest rate of Herosten (0.625 g/l) induced fruits (fingers) had significantly the heaviest peel weight as grams or percentage during both seasons of study. Contrary to that, the (T4/0.500g/l) of Herosten was the inferior, whereas resulted in inducing the lightest peel weight estimated as (g. and %) during both first and second seasons of study from the standpoint of statistic. On the other hand, the average of peel weight/finger as (g) and (%) of the other three treatments of (T1/control, T2 and T3) sprayed plants were significantly intermediate as compared to those of both the superior trend (T5= 0.625 g/l) and an inferior treatment (T4 = 0.500 g/l) sprayed plants. Such a trend was true during both seasons of study.

1-f. Pulp/peel ratio:

Concerning the Herosten foliar spray solutions with different rates on pulp/peel ratio of Williams banana finger, data obtained during both 2018 and 2019 seasons as shown from Table (8) revealed that banana plants "Williams cv." sprayed with Herosten at the rate of (0.500 g/l/T4) during the two experimental seasons of study induced fruits (fingers) contained statistically the highest value of pulp/peel ratio. On the other hand, the reverse trend was detected with (T5 = 0.625 g/l) sprayed plants which were resulted significantly in the lowest value in pulp/peel ratio throughout the first and second seasons of study. Moreover, the other investigated three sprayed treatments of the Herosten i.e., (0.00 g/l/control, 0.250 g/l, and 0.375 g/l) were in between the abovementioned two extents from the standpoint of the statistic as their effect on pulp/peel finger weight of Williams banana cultivar. Besides, differences between the three treatments (T1, T2 and T3) were so little to reach the level of significance in most cases. Such a trend was true during the 2018 and 2019 seasons of study.

Table 8. The response of fruit physical characteristics (peel weight as gms or percentage and pulp/peel ratio) of "Williams" banana cultivar to the different rates of Herosten spray solutions during the 2018 and 2019 seasons**.**

Parameters	Peel				Pulp/peel ratio	
	Weight (g)		Percentages (%)			
Treatments	2018	2019	2018	2019	2018	2019
T1: Control (Water spared)	44.73 b	41.44 c	39.69 b	35.94 c	1.52 bc	1.78 b
T2: Herosten at 0.25 g per liter**.**	37.73 c	44.63 b	38.15 b	41.50 b	1.62 bc	1.41 c
T3: Herosten at 0.375 g per liter.	32.90 d	38.43 d	32.11 c	35.13 d	2.12 b	1.85 b
T4: Herosten at 0.50 g per liter.	11.80 e	12.75 e	12.51 d	13.19 e	7.02 a	6.58 a
T5: Herosten at 0.625 g per liter.	48.32 a	53.07 a	43.10 a	45.39 a	1.32 c	1.20 d

Means followed by the same letter/s within each column didn't significantly differ at 5% level.

2- Chemical characteristics:

2-a. Total soluble solids percentage (TSS %):

Obtained data in **Table (9)** shows a positive relationship between fruit TSS (%) of "Williams" banana cultivar and Herosten foliar sprayed rate during both 2018 and 2019 of the experimental seasons of study. However, sprayed banana plants with the higher rate of Herosten (0.625 g/l/T5) induced fruits had the highest TSS (%) followed by the treatments of (T3, T2 and T4), respectively during both seasons. Whereas, the control treatment (T1) which was sprayed with tap water produced fruits had the lowest statistically value of TSS (%) and ranked last in this concern. Moreover, it is quite evident that the differences in fruit TSS (%) due to variable rates of Herosten foliar spraying were significant as they were compared each other from one hand and with the control from compared another one during the first (2018) and second (2019) seasons of study.

2-b. Total titratable acidity percentage:

Referring to the fruit acidity percentage as influenced by the various rates of sprayed treatments with Herosten, data in **Table (9)** declared that, the "Williams" banana plants sprayed with both treatments (T5 = 0.625 g/l) and (T1/control = 0.00 g/l) during both seasons induced fruits contained statistically the highest acidity (%). Contrary to that, the sprayed treatments of (T2, T3 and T4) Herosten rates resulted in the lowest values of fruit acidity percentage from the standpoint of statistic and differences were significantly the same as they compared each other during both the first and second seasons of study.

2-c. Total soluble solids (%), total acidity (%) and TSS/acid ratio:

Concerning the effect of the different investigated rates of Herosten sprayed solutions on TSS/acid ratio in "Williams" banana fruits, data obtained during both 2018 and 2019 seasons as shown from **Table (9)** indicated clearly that, the treatment (3) i.e., (0.375 g/l) was superior and exhibited statistically the highest value of TSS/acid ratio followed significantly by both (T2 and T4) during both experimental seasons.

Table 9. Effect of Herosten on TSS (%), acidity (%) and TSS/acidity ratio of Williams banana plants during 2018 and 2019 experimental seasons

Parameters	TSS (%)		Acidity (%)		TSS/acidity ratio	
Treatments	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
T1: Control (Water spared)	23.810 e	23.96 e	0.417 a	0.408 a	46.17 d	47.71 a
T2: Herosten at 0.25 g per liter**.**	25.280 c	25.520 c	0.385 b	0.375 b	51.64 b	54.95 a
T3: Herosten at 0.375 g per liter.	26.320 b	26.290 b	0.376 b	0.382 b	56.23 a	56.83 a
T4: Herosten at 0.50 g per liter.	24.890 d	24.910 d	0.386 b	0.363 b	51.61 b	54.42 a
T5: Herosten at 0.625 g per liter.	32.710 a	32.800 a	0.431 a	0.426 a	48.52 c	65.83 a

Means followed by the same letter/s within each column didn't significantly differ at 5% level.

2-d. Total carbohydrates (%):

As for the effect of the different rates of Herosten in the foliar sprayed solutions on total carbohydrates content of "Williams" banana plants, data obtained in **Table (10)** indicated obviously that, the response was completely absent from the standpoint of statistic, especially in the second season. In other words, total carbohydrate contents of banana plants sprayed with any rate of Herosten and tap water (control) were statistically the same in the 2019 (second) season. Moreover, in the first one, (2018) the Herosten foliar spray at either rate of (0.625 and 0.375 g/l) exhibited statistically the greatest values in total carbohydrates contents of "Williams" banana plants. However, both treatments with rates (0.500 and 0.250 g/l) were relatively were effective than the control treatment, but the differences didn`t reach the level of significance between the abovementioned two treatments. Meanwhile, the control treatment (banana plants sprayed with tap water) was statistically inferior as resulted significantly in the least value in this respect.

2-e. Starch (%):

Regarding an influence of the different Herosten foliar spray treatments at various rates on starch content, data in **Table (10)** showed clearly that, starch content responded statistically to the different rates of Herosten foliar spray solution as compared to the control treatment (banana plants sprayed with tap water) during both 2018 and 2019 seasons of study. However, the greatest and value contents of starch were significantly resulted by those "Williams" banana plants sprayed with (T5) treatment viz (0.625 g/l) from Herosten, followed statistically by those of both (T4 = 0.500 g/l) and (T3 = 0.375 g/l) in the first season and (T4=0.500 g/l) in the second season, but the differences did not reach the level of significance between treatments the first (2018) season. Moreover, during both seasons of study, the control banana plants of the "Williams "cultivar i.e., that sprayed with tap water (0.0 g/l Herosten (were statistically inferior as induced the least values of starch content.

Table 10. Effect of Herosten on Total carbohydrates and Starch of Williams banana plants during 2018 and 2019 experimental seasons

Parameters	Total carbohydrates (%)		Starch (%)	
Treatments	**2018**	**2019**	**2018**	**2019**
T1: Control (Water spared)	19.24 c	19.48 a	1.65 c	1.62 d
T2: Herosten at 0.25 g per liter**.**	19.86 b	20.60 a	1.91 b	1.94 c
T3: Herosten at 0.375 g per liter.	21.16 a	21.68 a	1.99 ab	2.04 bc
T4: Herosten at 0.50 g per liter.	19.92 b	19.92 a	2.05 ab	2.07 b
T5: Herosten at 0.625 g per liter.	20.93 a	28.12 a	2.17 a	2.19 a

Means followed by the same letter/s within each column didn't significantly differ at 5% level.

2-f. Total sugars (%):

Obtained data regarding the response of total sugars content of "Williams" banana cv. plants to the investigated different rates treatments of Herosten foliar sprays are tabulated in **Table (11)**. It was quite evident to be observed that, the total sugar content was affected by the studied treatments. However, the highest significant values of total sugars (%) were always significantly concerning such treatments of (T3 and T5) in the first season and (T2 & T5) in the second one, respectively. Meanwhile, both treatments of (T2 and control) in the first season and (T3) in the second one were ranked statistically the second. In addition to that, an opposite trend was observed with treatment (T4/0.500 g/l) which resulted significantly in the least value of total sugars (%) during both the 2018 and 2019 seasons.

2-g. Reducing-sugars (%):

As for the effect of the different rates of Herosten in foliar spray solutions, it could be noticed obviously from data represented in the same Table during both seasons of study that, reducing sugars (%) responded significantly. However, (T3 = 0.375 g/l) foliar spray rate of Herosten had fruits contained the greatest and the highest value of reducing sugars (%). Also, the superiority of the abovementioned treatment over the other investigated ones in all cases was observed during the two seasons of study. On the other hand, an opposite trend was detected with those banana plants sprayed with the higher rates of Herosten i.e., (T5=

0.625 g/l) in both seasons of study which had significantly the poorest fruits in their reducing sugars (%). Moreover, other remain treatments were intermediate regarding their effect on reducing sugars (%) of "Williams" banana plants from the standpoint of statistics during both the 2018 and 2019 seasons of study.

2-h. Non-reducing sugars (%):

Concerning the effect of the different spray solutions of Herosten rates on non-reducing sugars (%) in "Williams banana fruits, data in **Table (11)** revealed obviously that, the highest values of non-reducing sugars (%) in banana fruits was always concomitant to those banana plants sprayed with (T5 = 0.625 g/l) which was statistically superior treatment in this concern, followed statistically in descending order by both treatments (T2 = 0.250 g/l) and (T1 = control) which ranked statistically second and third, respectively as compared to the superior treatment. Such a trend was true during both the first and second seasons of study. On the other hand, the reverse trend was noticed with both treatments i.e., (T4 = 0.500 g/l) and (T3 = 0.375 g/l) in the first and second seasons, respectively were exhibited statistically the least values of non-reducing sugars (%) in banana fruits.

Table 11. Effect of Herosten on Total sugars (%), reducing sugars and Non reducing sugars of Williams banana plants during 2018 and 2019 experimental seasons

Parameters	Total sugars (%)		Reducing sugars		Non-reducing sugars	
Treatments	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
T1: Control (Water spared)	15.89 b	16.05 c	5.32 c	5.35 b	10.57 c	10.70 c
T2: Herosten at 0.25 g per liter**.**	15.90 b	16.98 a	4.57 d	4.66 bc	11.33 b	11.99 b
T3: Herosten at 0.375 g per liter.	16.94 a	16.65 b	6.57 a	6.85 a	10.37 c	9.80 e
T4: Herosten at 0.50 g per liter.	15.42 c	15.49 d	5.93 b	5.15 b	9.49 d	10.34 d
T5: Herosten at 0.625 g per liter.	16.84 a	16.89 ab	3.53 e	4.11 c	13.31 a	12.78 a

Means followed by the same letter/s within each column didn’t significantly differ at 5% level.

Discussion

Auxins are hormones first detected in plants, and later, gibberellins and cytokinins have also been discovered. Over the last 50 years, a tremendous amount of research has been done in the country on various aspects, such as varieties, cultivation, irrigation, training and pruning, etc., to improve fruit yield and quality. The processing of bad fruit is a matter of general knowledge. It would also be worthwhile to boost the yield and quality of fruit crops through the foliar application of plant growth regulators The use of plant growth regulators has assumed an integral part of modern crop farming to increase the production of quality fruit. Plant hormones or regulators are organic chemical compounds that, when used in a limited concentration, alter or control physiological processes to an appreciable degree in a plant. They are easily absorbed and travel efficiently through the tissues when added to various areas of the plant. These chemicals are unique to their behavior. In other words, plant growth regulators are organic substances (other than nutrients) that facilitate, inhibit, or otherwise alter some physiological processes in plants in limited quantities. As a result, the use of plant growth regulators has resulted in some outstanding achievements in several fruit crops in terms of growth, yield and efficiency. Physiological reactions that are currently regulated/influenced by PBR are-Promotion of plumage and branching, Increase flower bud formation inhibits flower bud formation, Thinning by the promotion of fruit/flower abscission, Retardation of pre-harvest decrease, Improve fruit finish, Improve fruit shape, Regulation of vegetative growth, Increase fruit color red, Advanced fruit ripening, Delay fruit ripening, Enhance rooting, Eliminate water sprout growth, Increase stress tolerance **Lawes and Woolley (2001)**.

In addition, the results obtained regarding the positive impact of Auxins are partly consistent with the findings of **Maibangra and Ahmed (2000)**, which treated the pineapple plant with 100 ppm NAA, and increased yield compared to control was observed. **Ingle *et al.*, (2001)** found that the foliar application of NAA at 30 ppm increased the fruit weight, acidity, juice percent peel and yield over control in Nagpur mandarin. In an experiment on the influence of atmospheric temperature and defoliation on flower bud induction with chemicals in pineapple, **Sawale *et al.*, (2001)** observed a substantial superior quality of TSS fruit, acidity and ascorbic juice content. **Yadav *et al.*, (2001)** concluded that fruit weight, organoleptic ranking, TSS, ascorbic acid and total sugar content of guava fruits increased significantly over control by applying NAA at 20 to 60 ppm and reduced fruit pressure (kg/cm2) significantly to make it more appropriate. **Yeshayahu *et al.*, (2001)** stated that spray of 300 ppm NAA increased fruit size in ‘Myovaze Satsuma’ mandarin and NAA also thinned the fruit-lets and decreased total yield. **Banghel and Tiwari (2003)** concluded that spray of 6 % urea and 150 ppm NAA in mango found superior for increasing the total number of flowers/panicle and percentage of hermaphrodite flowers. Maximum flowering and fruiting and number of fruits/trees, however, were reported under the combined application of 4 percent urea and 150 ppm NAA. **Greenberg *et al.*, (2006)** observed the influence of NAA 300 ppm spray on yield, fruit size, fruit consistency, fruit splitting and the occurrence of creasing in 'Nova' mandarin. Early

NAA spray, thinned fruit lets, increased fruit size, reduced splitting to 30%, decreased the incidence of creasing to 28 % compared to 36 percent in the control and had no effect on the yield. **Harhash and Al-Obeed (2007)** Studied the influence of different concentrations of NAA in Barhee and Shahi date palm cultivars on bundle weight and physical and chemical properties over the two years 2005 and 2006. They found that the application of NAA (0, 50, 100, 150 and 200 ppm) to Barhee and Shahi cultivars fruit. 10 weeks after the depressing cycle of fruit set, the application of 150 ppm NAA increased yield and improved fruit quality. **Stern *et al*., (2007)** the application of 25 ppm of 2,4-dichlorophenoxyacetic acid (2,4-D) plus 30 ppm of naphthalene acetic acid (NAA; 0,3 % of Amigo TM) was recorded at the beginning of pit-hardening when the fruitlet diameter was ca. 13 mm resulted from inappreciable and significant changes in fruit size and overall yield, even when the crop load was high. **Nawaz *et al*., (2008)** studied the effect of foliar sprays of NAA at 10, 15 and 20 ppm in Kinnow mandarin and maximum Vitamin C contents (45.30 mg/100g) was found in 15 ppm NAA. **Iqbal *et al*., (2009)** applied with 15, 30, 45, 60, 75 and 90 ppm NAA through the foliar spray and reported that 45 ppm spray reduced pre-harvest fruit drop, increased yield, pulp/acid ratio (11.31), TSS (11%), total sugar (7.45%), acidity and ascorbic acid in guava. **Asin *et al*., (2010)** observed that application of NAA at 40 ppm in pear cv. 'Conference' and 'Blanquilla' and improved fruit retention percent and fruit yield. **Hasami and Abdi (2010)** found that NAA at 100 ppm increased bunch weight, improved physical properties (fruit weight, height, diameter and size), decreased TSS, total and reducing sugar in date palm. **Kassem *et al*., (2010)]** It was found that the use of NAA at pea stage and marble stage in 'Costata' persimmon significantly increased vegetative growth, fruit retention and fruit yield in both seasons. **Ghosh *et al*., (2012)** Application of different doses of NAA at 15, 20, 25 and 30ppm and found that NAA spray at 15 ppm was most effective in minimizing fruit drops at different months after fruit set, resulting in a doubling of fruit yield compared to control and increased fruit size in sweet orange.

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تأثير استخدام التركيزات المختلفة من مركب الهيروستين علي الانتاجية وصفات الجودة في الموز الويليامز

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أجريت هذه الدراسة على الخلفة الأولى والثانية لنباتات الموز صنف ويليامز والمزروعة في أرض طينية خفيفة وتروي بالغمر في مزرعة محطة بحوث القناطر الخيرية بالقليوبية والتابعة لمركز البحوث الزراعية خلال موسمين متتاليين 2018 و2019 وكانت مسافات الزراعة 3 × 4 م وذلك بغرض تحسين الانتاجية وصفات الجوده من خلال الرش مركب الهيروستين المحتوي علي 4.5 % اوكسين. وتم الرش خمس مرات خلال كل موسم تجريبي في الفترة من بداية شهر يوليو الي بداية شهر نوفمبر بمعدل رشه واحدة في بداية كل شهر وكان معدل مجلول الرش المستخدم 0.5 لتر للنبات الواحد وعلية واشتملت هذه الدراسة علي خمسة معاملات كالتالي: المعاملة الأولى الكنترول 100(الرش بالماء), المعاملة الثانية الرش بمركب الهيروستين بتركيز0.25 جرام للتر, المعاملة الثالثة الرش بمركب الهيروستين بتركيز 0.375 جرام للتر, المعاملة الرابعة الرش بمركب الهيروستين بتركيز 0.50 جرام للتر و المعاملة الخامسة الرش بمركب الهيروستين بتركيز0.625 جرام للتر.وتم دراسة مدى استجابة نباتات الموز صنف ويليامز للمعاملات المختلفة من خلال التغيرات في بعض القياسات الفينولوجية والانتاجية وكذلك الصفات الطبيعية والصفات الكيماوية للثمار. أوضحت النتائج المتحصل عليها تفوق جميع معاملات الرش المستخدمة مقارنة بالكنترول (الرش بالماء) في حين كانت أفضل المعاملات في هذا الصدد هي المعاملة الثالثة (الرش بركب الهيروستين بتركيز0.375 جرام للتر) والتي ادي أستخدامها التبكير في الحصاد وقصر دورة حياة النبات وزيادة الانتاجية وتحسين صفات الجودة وذلك خلال موسمي الدراسة وبالتالي يمكن التوصية بها. يليها المعاملة الرابعة (الرش بركب الهيروستين بيركيز 0.50 جرام للتر) في المركز الثاني من الناحية الاحصائية خلال موسمي الدراسة.