Original Article

Responding Yield and Fruit Quality of Salmy Date Palm Cultivar by Foliar Application of Gibberellic Acid and Humic Acid

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Abstract

Many researchers seek to increase the productivity of date palm and improve the fruit quality in most countries of the world. Therefore, the aim of this study was influence both GA3 at (100 & 200 ppm) and humic acid at (10 & 20 cm/L) individually or collectively on productivity and fruit quality of the promising dates Salmy cultivar. The present study was carried out during 2018 and 2019 seasons on 10 years old Salmy date palm. The inflorescences were sprayed at three times (the first was 3 hours before pollination, the second was 4 week after pollination and the third was 8 week after pollination). In general, all tested treatments were significantly increased bunch weight, yield and fruit quality (physical and chemical properties) in both seasons as compared with control. Spraying inflorescences of Salmy date palm with the combined treatment (200 ppm GA3 + 20 cm/L humic acid) was the best treatment in this regard and a good recommendation to increase the production and improvement fruit quality of Salmy date palm cultivar under the current study conditions.

Keywords: Salmy date palm cultivar, Gibberellic acid, humic acid, yield, fruit quality.

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INTRODUCTION

Date palm is one of the oldest fruit trees in the world, especially in the Middle East. It is known as “tree of life” because of its flexibility, its need for limited water inputs, its long term productivity and its multiple purpose qualities. Egypt is considered the leading country among the top ten date producers. Date palm cultivar "Salmy" is one of the most promising dates in Egypt. It is usually harvested and consumed at Khalal stage when fruits reach full maturity and are crunchy yellow. In fact, dates consumers and growers are looking for fruits with bigger size and better color. Furthermore, keeping forward this position in view, increased yield and improved fruit quality of date palm became a main target for many researchers in Egypt.

The use of growth regulators to increase fruit yield has become important in agriculture today with the purpose of enhancing vegetative growth, fruit set, yield and quality attributes. Gibberellic acid has been utilized in improvement, increasing fruit yield and enhancing fruit physical and chemical properties [1, 2, 3, 4, 5, 6 and 7].

Humic acid (polymeric polyhydroxy acid) is one of the most important organic fertilizers used in this field and is an organic acid and humic compounds produced naturally resulting from the decomposition of disparate molecular organic materials. Also, it is a natural compound that has many physiological and biological benefits on plants, physical, chemical and biological soil. Moreover, the role of humic acid is similar to the role of auxins in cell division, which promotes plant growth and leaves as well as no harmful effects to humans and plants [8, 9, 10 and 11].

So, the main objective of this work was to study the effects of foliar applications of Gibberellic acid and humic acid alone or combined on quantitative and qualitative yield responses of Salmy date palm cultivar.

MATERIALS AND METHODS

The present study was carried out during 2018 and 2019 seasons on 10 years old Salmy date palm (Phoenix dactylifera L.) grown on sandy soil with 6x6 meters apart under drip irrigation system at a private orchard located point of 63 kilo meter on Cairo-Alexandria desert road. The selected palms 27 trees were healthy, nearly uniform in growth vigor and fruiting and received regular horticultural practices. In addition, pruning was performed to maintain bunch/mature leaves ratio to 1:8, respectively. The number of spathes per palm was edited to 10 bunches by removing excess earliest, latest and smallest inflorescence. Pollination was carried out using

the same pollen grain source during both seasons of the study. Twenty seven date palms were selected and divided into nine treatments in three replicates (each replicate as one palm) and arranged in a Randomized Complete Block Design as follows:

(T1) Control (treated with water only).
(T2) 100 ppm Gibberellic acid (GA3)
(T3) 200 ppm Gibberellic acid (GA3)
(T4) 10 cm/L Humic acid (HA)
(T5) 20cm/L Humic acid (HA)
(T6) 100ppm GA3 + 10 cm/L HA
(T7) 100ppm GA3 + 20 cm/L HA
(T8) 200ppm GA3 + 10 cm/L HA
(T9) 200ppm GA3 + 20 cm/L HA

All spray treatments were thoroughly applied on inflorescences using a small hand sprayer (5 liters capacity) until run-off. Gibberellic acid and humic acid were sprayed for three times (the first was 3 hours before pollination, the second one 4 week after pollination and third one 8 week after pollination). The response of "Salmy" date palms to Gibberellic acid and humic acid and their combinations were evaluated through the following measurements:

Bunch Weight and Yield/palm (Kg)

In the two seasons, bunches were harvested at the mid-September at the peak of color
development, and have been counted and weights (Kg) were recorded. Then, we calculated the average of yield (Kg)/palm.

Fruit Physical Characteristics

Samples of 10 fruits were randomly taken form each bunch on the experimental palms. The fruit weight (g) and fruit dimensions (cm), flesh and seed weight (g), and fruit shape index were determined.

Fruit Chemical Characteristics

Total soluble solids percentage (TSS %) was determined by using hand refractometer. Total acidity percentage (TA %) was measured as malic acid and determined by [12], and then T.S.S./Acid ratio was calculated. Total sugars, reducing and non-reducing sugars percentages were determined according to [12].Vitamin C (VC) as Ascorbic Acid Content (mg/100 mL juice) was measured and using 2,6 dichlorophenol indophenol's blue dye, method described by [12].

Statistical Analysis

The experiment was arranged in Randomized Complete Block Design. The obtained data were statistically analyzed [13] using LSD parameter at 5% level for comparing the differences between the studied treatment means.

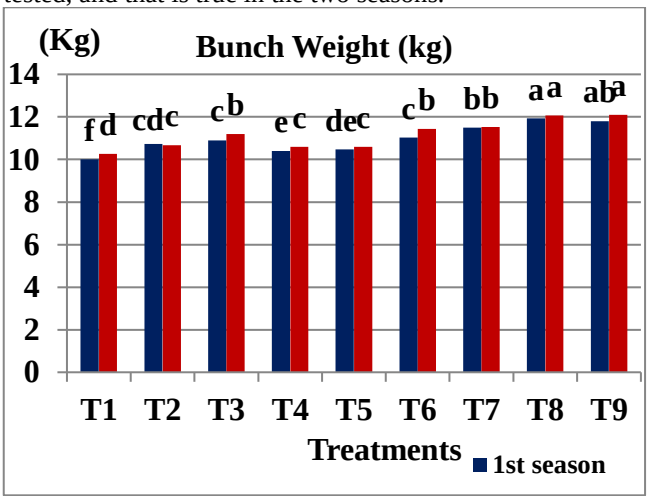
RESULTS AND DISCUSSION

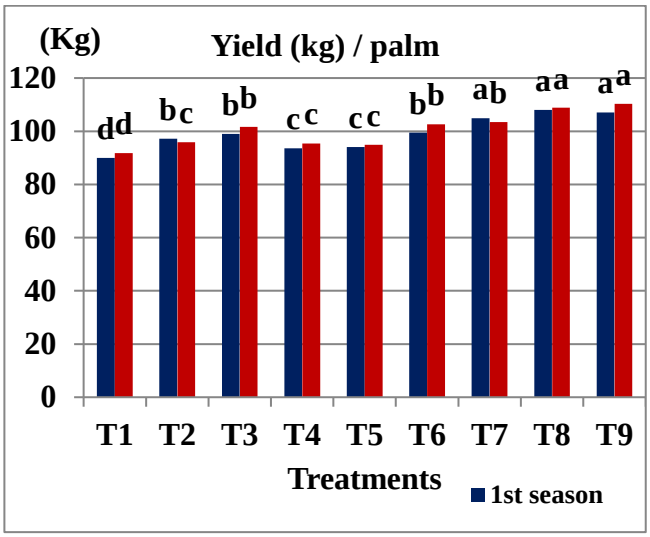
Bunch Weight (Kg) and Yield (Kg)/palm

From the first look at Figure (1), noticed that bunch weight and yield/palm of Salmy date palm were significantly affected by different foliar applications when compare by the control treatment in both studied seasons.

As for bunch weight, foliar application of Salmy inflorescences with the combined treatments, it found that 200 ppm GA3 + 20 cm/L HA (T9) and 200 ppm GA3 + 10 cm/L HA (T8) reflected heaviest significant values of bunch weight, with no significant differ among them in both seasons. The treatments 100 ppm GA3 + 20 cm/L HA (T7), 100 ppm GA3 + 10 cm/L HA (T6) and 200 ppm GA3 (T3) came the next, with no statistical through them in the two seasons, except T7 in the first season. The previous treatments increment bunch weight (Kg) about control by (18 & 17.8 %), (19.3 & 17.53 %), (15&12.27%), (10.3 & 11.30 %) and (9 & 9.10 %) respectively in the 1st and the 2nd seasons. In contrast, the control treatment scored lighter statistical values in this regard. Meanwhile, the other treatments were given intermediate.

According to the yield/palm, data indicated that, the highest significant values of yield were registered by the combined treatments T9 and T8 with no significant difference between their in the two seasons, except T7 in the 2ndseason. Tested treatments T6, T3 and T2 (100 ppm GA3) came the next, with no significance among them except T2 in the 2nd seasons. Followed by T5 (20 cm/L HA) and T4 (10 cm/L HA), with not statistical between them in both seasons. The above treatments were increasing the yield (Kg) /palm nearby control with (19 & 20.10 %), (20 & 18.63 %), (16.50 & 12.75 %), (10.50 & 11.77 %), (10 & 10.78 %), (8 & 4.41 %), (4.50 & 3.43 %) and (4 & 3.92 %) consecutively in both seasons. Other vise, the lowest yield/palm was recorded by untreated tested, and that is true in the two seasons.





T1: Control (water only), T2: 100 ppm GA3, T3: 200 ppm GA3, T4: 10 cm/L Humic Acid (HA), T5: 20 cm/L HA, T6: 100 ppm GA3 + 10 cm/L HA, T7: 100 ppm GA3 + 20 cm/L HA, T8: 200 ppm GA3 + 10 cm/L HA, T9: 200 ppm GA3 + 20 cm/L HA.

Figure 1. Bunch weight and yield of Salmy date palm as affected by foliar application of Gibberellic acid and humic acid alone or combined during the two seasons

These results may be due to the interaction between GA3+ HA at the two levels which enhancing and improving bunch weight (Kg) and yield (Kg)/palm, it could be attributed to their effects in increasing fruit set and fruit retention. Gibberellins have been successfully used for many purposes including improved bunch weight and yield/palm may be due to the role of GA3 through cell division and cell enlargement in the meristem cells of flowers, which induced a positive effect on decreased fruit drop and increasing fruit set and retention percentages. In this respect, [1] found that GA3 treatment produced the heaviest bunches and yield/tree (kg) was significantly increased by GA3 treatment at 50 and 100 ppm in the 1st and 2nd seasons. The obtained results confirm those obtained on date palm since the application of GA3 on dates at 100 or 150 ppm significantly increased bunch weight, fruit and flesh weight, fruit diameter and length ([14, 3, 15 and 4].

Also, using humic acid have great potential improve soil structure and change physical properties, promote the chelation of many elements and make these available to plants. Enhancement of total chlorophyll contents, stomatal conductance, net photosynthesis rate and transpiration rate has resulted in greater plant growth; this is reflected in an increase in yield and fruit quality. In this regard, our results agree with those obtained by [16] who concluded that humic acid caused the highest yield as number of fruits/tree or weight (kg/tree) compared with untreated trees of mandarin. On the other hand, [17] showed that Kinnow mandarin tree received humic acid at 30 ml exhibited highest number of fruits per tree.

Fruit Physical Characteristics

A glance to Table (1) indicated that all treatments under study approximately gave the same direction on influence of Salmy fruits physical characteristics. Data showed that fruit weight, (flesh & seed) weight, fruit dimensions (length & diameter) and fruit shape indexes were enhanced by different treatments.

As for fruit weight, the present results demonstrated that, all tested treatments caused significant in average of Salmy fruit weight compared with control in both seasons Table (1). The heaviest fruit weight was detected by foliar application by the combined treatments (T8), (T9) and (T6) with high significance differ among them in the two seasons except T6 in the 2nd seasons, which recorded (7.45&7.75gm), (7.00 & 7.10 gm)and (6.75&7.00 gm) respectively in the 1st and the 2ndseasons. While, T7 (6.45 & 6.70 gm) and T3 (6.35 & 6.50 gm) came after consecutively in both seasons of study, with no statistical differences between them. The lowest fruit weight was recorded (5.30 & 5.40 gm) from the control, sequentially in the two years. The remains of tested treatments came in between them.

Regard to flesh weight, data in Table (1) cleared that fruit flesh weight increased significantly affected by differed treatments as compared with control and gave the same trend of fruit weight in the 1st year. While in the 2nd years, T8 was more effective than T9, T7 and T6 on fruit flesh weight. Meanwhile, control treatment gained the lowest value in this respect in both seasons. The other tested treatments recorded intermediate values.

Data in Table (1), reference that seed weight of Salmy date palm was decreased significantly affected by different treatments in both seasons. The lowest seed weight was registered from (T8, T9 and T7) in the first year, but from treatments (T7, T9, T8, T6, T2 and T3) in the second years. Meanwhile, the highest seed weight was obtained from the treatments (T4, T5 and T1) in the 1stseason and (T5, T4 and T1) in the 2nd seasons.

Concerning fruit dimensions, our results indicated that fruit dimensions (fruit length and diameter "cm") were significantly affected by different treatments in both seasons Table (1). Regard to fruit length, foliar application of Salmy inflorescences was more effect by T8 followed by T9, T6 and T2 respectively, registered highest fruit length in the first year. Whereas, the treatments T9 and T8 followed by T6 and T7 recorded in this regard in the second years. On the other hand, the lowest values of fruit length were obtained from treatments T4, T5 and T1consecutively, in both seasons.

Concerning fruit diameter the highest increase were achieved from treatments (T9, T8, T3 and T6 followed by T7, T2, T3 and T4 in the 1st season. While in the 2nd seasons, the treatments (T8 and T9) followed by T7, T6 and T3 in this respect. Furthermore, the lowest significant of fruit diameter recorded from inflorescences treated with water only (T1).

From results in Table (1) fruit shape index revealed that fruit shape index as affected statistically by all tested treatments. The highest increments in this character were

obtained by treatments T1, T8, T9 and T2 in 1st season, without significant differences among them. Whilst, the treatments T9 and T8 were recorded in this respect in the 2nd seasons, with no statistical differ between other. In contrast, the lowest significant of this parameter achieved from treatments T5, T4 and T3 in the first year as well as from treatments T4 and T5 in the second years, with no significance differ among them.

These results the enhancement effect on fruit physical characteristics may be due to the mode of action and the effect of the interaction between GA3and humic acid. This is consistent with [18] where he found that spraying of GA3 at 150 ppm, as well as, HA at 5 and 4% were the superior treatments and showed the most significant impact on plant growth, yield, fruit quality and leaf mineral content of pear. Our results were agree with [1] who indicate that foliar spray with GA3 recorded the maximum fruit weight, fruit flesh weight, the maximum values of fruit length and diameter in the 1stand 2ndseasons, while control treatment gained the lowest in this connection in both seasons. Also, the increase in fruit dimensions could be attributed to the effect of Gibberellic acid since it stimulate both cell division and cell enlargement. Similar observation was reported by many investigators who found that fruit dimensions were increased when fruits received Gibberellic acid spraying ([19 and 20]. Moreover, these results are in harmony with those recorded on date palms, that since spraying GA3 increased average fruit weight, flesh weight, fruit length and fruit diameter [2, 1, 21and 7]. Moreover, [22] he emphasized that humic acid is a natural biological organism, which promotes plant growth, the role similar to the role of auxins in cell division, which has a major impact on plant growth and fruit quality. These results are similar to that achieved by [10, 23 and 10].

Table 1. Fruit physical characteristics of Salmy date palm as affected by foliar application of Gibberellic acid and humic acid alone or combined during the two seasons

Treatments	The first season					
	Fruit weight (gm)	**Flesh weight (gm)**	**Seed weight (gm)**	**Fruit length (cm)**	**Fruit Diameter (cm)**	**Fruit shape index**
Control (water only)	5.30	3.83	1.37	2.55	2.00	1.27
100 ppm GA_3	5.90	4.67	1.27	2.75	2.25	1.19
200 ppm GA_3	6.35	5.20	1.20	2.65	2.40	1.13
10 cm/L HA	5.45	4.10	1.40	2.50	2.25	1.12
20 cm/L HA	5.90	4.50	1.37	2.40	2.25	1.07
100 ppm GA_3 + 10 cm/L HA	6.75	5.57	1.20	2.80	2.35	1.18
100 ppm GA_3 + 20 cm/L HA	6.45	5.47	1.17	2.60	2.30	1.14
200 ppm GA_3 + 10 cm/L HA	7.45	6.33	1.10	3.00	2.40	1.25
200 ppm GA_3 + 20 cm/L HA	7.00	5.80	1.13	2.85	2.40	1.21
LSD $_{0.05}$	**0.29**	**0.29**	**0.08**	**0.12**	**0.08**	**0.07**
Treatments	**The second seasons**					
	Fruit weight (gm)	**Flesh weight (gm)**	**Seed weight (gm)**	**Fruit length (cm)**	**Fruit Diameter (cm)**	**Fruit shape index**
Control (water only)	5.40	3.93	1.28	2.50	2.05	1.21
100 ppm GA_3	6.20	5.03	1.20	2.65	2.30	1.14
200 ppm GA_3	6.50	5.30	1.23	2.65	2.40	1.10
10 cm/L HA	5.70	4.23	1.47	2.40	2.35	1.03
20 cm/L HA	6.00	4.53	1.43	2.50	2.30	1.07
100 ppm GA_3 + 10 cm/L HA	7.00	5.77	1.20	2.90	2.40	1.18
100 ppm GA_3 + 20 cm/L HA	6.70	5.83	1.10	2.75	2.40	1.13
200 ppm GA_3 + 10 cm/L HA	7.75	6.53	1.13	3.10	2.50	1.26
200 ppm GA_3 + 20 cm/L HA	7.10	5.97	1.10	3.10	2.45	1.29
LSD $_{0.05}$	**0.30**	**0.33**	**0.16**	**0.14**	**0.07**	**0.06**

Fruit Chemical Characteristics

The results in Table (2) cleared that all tested treatments markedly affected on chemical characteristics of Salmy fruits. As a general, GA3 and HA treatments alone or combined achieved the highest significant values for all fruit chemical characteristics, except fruit acidity and non reducing sugars in both seasons. Control treatment gave the lowest values for all chemical fruit characteristics.

From Table (2), date showed that TSS% ranged from (27.83 to 30.53 %) and from (27.87 to 31.67 %) compared with the control (27.43 & 27.37 %) respectively in both seasons. The best results were obtained from the combined treatments and T8 had more effective in this parameter, consecutively in the two seasons. Followed by T7 and T6 and that is true in both seasons. Whereas, the

lowest significance values of TSS % were revealed from the control.

Results in Table (2) indicated that general of all, TA % ranged from (0.18 to 0. 20 %) and from (0.19 to 0.20 %) compared as control was (0.22 & 0.21%), alternately in the two seasons. All tested treatments gained the lowest significant total acidity percentage in the 1st season. T8 was more effective in this respect which recorded 0.18 %, followed by those treatments T9, T7, T6, T5 and T4 with no statistical differ between them in the first season, all of them registered (0.19 %). While, water spray (control) gave the highest fruit acidity percentage in the 1st and 2nd seasons, respectively, with significant differences between all tested treatments in the 1st season only. In contrast in the 2nd seasons, although all tested treatments gave lowest TA % but without any significant between them including control.

As for reducing sugars, the best results for this parameter were registered by T9 and T8, followed by T7 and T6 in the 1st season. Meanwhile, for the 2nd season, the best treatments were obtained from T9, T8 and T7. Followed by, T3 and T5 respectively. The other treatments gave intermediate between other. The lowest percentages of reducing sugars were recorded by the control in both seasons.

It could be noticed from Table (2) that non reducing sugars values were statistically similar for different tested treatments in the two seasons. It means that foliar spraying by GA3 + HA did not effect on non reducing sugars parameter.

Regard to the total sugars, it is noticed that trend of total sugars was similar to those of reducing sugars in the 2nd seasons.

Results of the ascorbic acid showed that Salmy palms treated with tested treatments and its combination reflected similar effect with non significant differences among them and took the same direction of reducing sugars in both seasons.

The progress in contents of total soluble solids, reducing, total sugars and ascorbic acid as well as reduction in total acidity in juice of Salmy date palm cultivar as foliar application with GA3 and humic acid alone or combined, may be attributed to the effect of natural hormones and Humic. It improved growth in all parts of the plant as a tonic for physiological processes in particular to enhance the process of photosynthesis and increases the yield moreover improves the quality characteristics. Similar results were reported by many authors such as [24, 21, 15, 1 and 4] spray GA3 on date palms. Also, those work on humic acid by (25, 26 and 22) as well as concerning the interaction, [18] who found that spraying of GA3 at 150 ppm and HA at 5 & 4% were the superior treatments and showed the most significant effect on fruit quality of pear.

Table 2. Fruit chemical characteristics of Salmy date palm as affected by foliar application of Gibberellic acid and humic acid alone or combined during the two seasons

Treatments	The first season					
	Total soluble solids (%)	Total Acidity (%)	Reducing sugars (%)	Non reducing sugars %)(	Total sugars %)(	VC (mg/100 mL)juice
Control (water only)	27.43	0.22	30.50	12.00	43.67	8.77
100 ppm GA_3	27.93	0.20	31.50	12.33	43.00	10.20
200 ppm GA_3	28.33	0.20	31.55	12.67	44.30	10.67
10 cm/L HA	27.83	0.19	30.80	12.33	42.67	10.37
20 cm/L HA	27.93	0.19	31.50	13.00	44.67	10.87
100 ppm GA_3 + 10 cm/L HA	29.30	0.19	32.00	12.67	45.00	11.60
100 ppm GA_3 + 20 cm/L HA	29.33	0.19	32.50	13.00	45.67	11.50
200 ppm GA_3 + 10 cm/L HA	30.00	0.18	33.55	12.67	46.03	12.30
200 ppm GA_3 + 20 cm/L HA	30.53	0.19	33.90	13.00	46.60	12.60
LSD $_{0.05}$	**0.54**	**0.01**	**0.86**	**NS**	**0.98**	**0.49**
Treatments	**The second seasons**					
	Total soluble solids(%)	**Total Acidity (%)**	**Reducing sugars (%)**	**Non reducing sugars %)(**	**Total sugars %)(**	**VC (mg/100 mL) juice**
Control (water only)	27.37	0.21	30.50	11.67	42.33	8.83
100 ppm GA_3	27.87	0.20	31.00	11.67	42.33	10.27
200 ppm GA_3	27.93	0.19	32.00	12.00	44.00	10.93
10 cm/L HA	28.00	0.20	30.50	12.33	43.00	10.60
20 cm/L HA	27.97	0.20	32.00	12.67	44.33	11.27
100 ppm GA_3 + 10 cm/L HA	29.83	0.20	31.50	13.00	44.67	11.87
100 ppm GA_3 + 20 cm/L HA	30.33	0.20	32.50	12.67	45.00	12.50
200 ppm GA_3 + 10 cm/L HA	31.33	0.19	32.80	13.00	45.80	12.50

200 ppm GA_3 + 20 cm/L HA	31.67	0.19	33.50	12.67	46.17	12.70
LSD $_{0.05}$	**0.84**	**NS**	**1.06**	**NS**	**1.55**	**0.34**

CONCLUSION

Our study proved that GA3 and HA improve fruit weight, fruit dimensions, total soluble solids, total sugars, and Vitamin C compared to the control. It also led to a positive increase in the quantitative and qualitative yield of the Salmy date palm cultivar. In addition, spraying of GA3 at 100 and 200 ppm as well as humic acid at 10 and 20 cm/L showed the most significant effect on the above characteristics. While their combined treatments, gave the best results in this regard. Thus, we can conclude that foliar application of Salmy inflorescences with the combined treatments (200 ppm GA3 + 20 cm/L humic acid) and (200 ppm GA3 + 10 cm/L humic acid) as well as treatments (100 ppm GA3 + 20 cm/L humic acid) and (100 ppm GA3 + 10 cm/L humic acid) were the best treatments and a good recommendation to increase the production and improvement fruit quality of Salmy date palm cultivar under the current study conditions. This study also provides a basis for the future elucidation of the modified GA3 and HA molecular mechanisms in date palm, which could make a significant contribution to the scientific community.

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