JSAES
Journal of Sustainable Agricultural and Environmental Sciences

Print ISSN : 2735-4377
Online ISSN : 2785-9878
Homepage: https://jsaes.journals.ekb.eg/

Research Article

The Effect of Spraying with Some Growth Regulators and Amino Compounds on Fruit Drops, Yield, and Fruit Quality and Rutability In 'Hayany' Date Palm

Usama K. A. ElAbbasy [1,*], El-Refaey F. A. El-Dengawy [2], Khaled H. A. AL-Hindi [1] and Ahmed F. Abd El-Khalek [1,*]

[1] Department of Horticulture, Faculty of Agriculture, Tanta University, Tanta, 31527, Egypt; usama.elabbasy@agr.tanta.edu.eg; ahmed.gameal@agr.tanta.edu.eg
[2] Department of Horticulture, Faculty of Agriculture, Damietta University, Egypt; dengawy@du.edu.eg
[*] Correspondence: Usama K. A. Elabbasy; usama.elabbasy@agr.tanta.edu.eg; Ahmed, F. Abd El-Khalek; ahmed.gameal@agr.tanta.edu.eg

Article info: -

Received: 20 February 2024
Revised: 26 March 2024
Accepted: 10 April 2024
Published: 30 May 2024

Keywords:
Hayany Date Palm, Growth Regulators, Amino Compounds, Fruit Quality, Rutability

Abstract:

This research was conducted to study the effect of spraying with 0.5 mM Naphthalene acetic acid (NAA), 2.5 mM salicylic acid (SA), 1 mM aspartic acid (ASP) and 1 mM putrescine (PUT) alone or in combinations on productivity and fruit quality of 'Hayany' date palm. Eight treatments were applied twice: at 30 days after complete hand pollination (ACHP) and at start of Khalal (Bisr) stage (16 weeks, ACHP). The result showed that 1 mM PUT treatment reduced fruit drops, especially in the kimri stage, and gave the highest fruit retention and palm yield. Oppositely, 1 mM ASP caused a significant increase fruit drops in both kimri and bisr stages and a significant reduction in palm yield compared the control and the other treatments. Moreover, spraying with 0.5 mM NAA or the combination between ASP and SA induced an improvement in yield of palm compared to the control. Spraying with 1 mM PUT improved the weight of fruit, flesh, and seed as well as increase fruit size. The combined treatment with 0.5 mM NAA + 1 mM ASP caused a significant increase in the soluble sugars content. Furthermore, all treatments produced a significant increase in the ascorbic acid content as compared to the control. In addition, spraying date palm with 0.5 mM NAA alone or in combination with 2.5 mM SA or 1 mM ASP decreasing fruit contents of anthocyanins, titratable acidity, total soluble solids, and a lack of rutability index. So, these NAA-treatments led to maintaining fruit quality of 'Hayany' dates.

1. Introduction

The date palm (*Phoenix dactylifera* L.) holds a remarkable religious significance in all major religions (Musselman, 2007). The palm tree grows well in semiarid and arid regions (Mohamed et al., 2014) of the Middle East and North Africa (Al-Khayri, 2001). Dates are the most popular fruit in the Middle East, which conclude over 90% of the annual world's date production (Ahmed, 1999); therefore, it is considered an ideal crop for low-income countries.

Egypt is a top ten leading global producer of palm date fruits, with a total production of 1.6 million tons annually (FAO, 2021), with Zaghloul, Samany, Hayany and Sewi being the most economically significant cultivars (El-Badawy et al., 2018). Although, the climate in Egypt is considered suitable for palm trees to grow (El-Dengawy et al., 2018), various stresses including drought, abrupt temperature changes, high rainfall, heavy crop load and nutrient deficiency or imbalance can cause fruits drop, deteriorate fruit quality, and ultimately leads to lower production (Racsko et al., 2007 and Robinson et al., 2010). Additionally, an imbalance in auxin and ethylene levels is believed to induce fruit drop (Wood, 2011).

The date palm cultivar 'Hayany' suffers from considerable fruit drops during the fruit development season, with the maximum drop occurring at the "Hababouk" stage and the "Khalal" stage, according to Ben Salah (2001) can range from 50-70%. 'Hayany' date cultivar, a dark brown color, is harvested and consumed at the Rutab stage, when all cane sugar is converted into invert or reducing sugars during ripening, with a moisture content over 30%. 'Hayany' dates cultivar's short shelf life and small fruit size hinder its marketing due to consumers seeking larger, higher-quality fruits. Improving quality, reducing drop fruits, and prolonging the khalal stage could expand the cultivar's marketing potential.

Foliar application of plant growth regulators and micronutrients has led to improved source: sink ratio and resulted in enhanced fruit set, growth, and overall quality with reduced fruit drop percentage (Maurya et al., 2020).

Salicylic acid (AS), a naturally phenolic substance in plants, regulates various physiological and biochemical processes, including nitrogen metabolism, photosynthesis, antioxidant defense, proline metabolism, and plant-water relations (Khan et al., 2012 and Hagagg et al., 2020). Additionally, SA is beneficial for maintaining fruit firmness and delaying fruit senescence by inhibiting ethylene biosynthesis (Khademi and Ershadi, 2013). It was

found that using salicylic acid at different concentrations in olive, Valencia orange, and Sewy date palm trees resulted in improvement of both production and quality (Abd El-Razek et al., 2013; Habasy, 2015 and Ahmed 2023). Naphthalene acetic acid (NAA) is a synthetic auxin that reduces preharvest fruit loss and enhances fruit softness (Yuan and Li, 2008 and Li and Yuan, 2008). NAA was observed to enhance date fruit size, weight, and delay ripening (Maurya et al., 2020). Amino acids are crucial cellular metabolites, building proteins and playing various metabolic roles (Akladious and Abbas, 2013). Recent studies suggest that amino acids, as biological stimulants, can enhance physiological characteristics (Xu et al., 2018). putrescine (PUT) is polyamine and considered as plant growth regulators with multiple functions, it is implicated in many processes of plant growth and development such as cell division and DNA replication (Galston and Kaur-Sawhney, 1988). PUT also is an anti-senescence, and anti-stress agent (Ahmed et al., 2017) According to Abo Sedera et al. (2010) and Akladious and Abbas (2013) Aspartic acid is crucial for plant metabolism and protein assimilation, enhancing fresh and dry matter, increased plant growth, the contents of anthocyanin, α-tocopherol, ascorbic acid and enzymatic activities in strawberry and tomato seedlings. The present study aims to reduce preharvest fruit drop and improve the yield and fruit quality of 'Hayany' dates in response to foliar application of NAA, SA, ASP and PUT.

2. Materials and Methods

The current study was conducted during the 2019 and 2020 seasons on 40 years old date palm (*Phoenix dactylifera* L.) cv. Hayany cultivated on sandy soil under furrow irrigation scheme at Kafer-Elbatikh village in a private orchard at 10 Km west Damietta Governorate, Egypt (Latitude: 31° 24' 59.99" N Longitude: 31° 48' 59.99" E), to study the effect of spraying the growth regulators (Naphthalene acetic acid and Salicylic acid) and amino compounds (Aspartic acid and putrescine) alone or in combinations on date fruits dropping, palm productivity, fruit quality and rutability. The trees were generally subjected to cultural procedures in this region. Twenty-Four palms were chosen in the similar growth and load as uniformly as possible and arranged in a randomized complete block design. All selected palms were pollinated by the same source of pollen grains and 8 bunches were left on each palm; therefore, leaf/ bunch ratio was 8:1 (El-Salhy, 2001). Eight spraying treatments were applied twice, at 30 days after complete hand pollination (ACHP) and at start of Khalal (Bisr) stage. Each treatment is replicated three times (16 weeks, ACHP) with one palm in each replicate. Two liters from spraying solution were used for each one date palm and treatments were applied as follows:

T1= Control, spraying the bunches and leaves with water only.
T2= Spraying the bunches and leaves with 0.5 mM NAA.
T3= Spraying the bunches and leaves with 2.5 mM SA.
T4= Spraying the bunches and leaves with 1.0 mMASP.
T5= Spraying the bunches and leaves with 1.0 mM PUT.
T6= Spraying the bunches and leaves with 0.5 mM NAA + 2.5 mM SA.
T7= Spraying the bunches and leaves with 0.5 mM NAA + 1.0 mM ASP.
T8= Spraying the bunches and leaves with 2.5 mM SA + 1.0 mM ASP.

The studied measurements were conducted as follow:

2.1. Fruits drop percentage and yield

2.1.1. Fruit drops (%)

One bunch was selected on each palm, and the selected bunches were at the same direction of south–west in all tested palms. Ten strands on each bunch were chosen, labeled and the fruits setting were counted on them at 3 times: 1) at the end of Hababouk stage (one month after pollination), 2) at start of Khalal (Bisr) stage and 3) at the harvest time, to calculate the fruit drop percentage using the following equations:

Kimri fruits drop (%) = [(Number of fruits setting/strand (at end of Hababouk stage)) - (retained fruits at start of Khalal stage)]/[(Number of fruits setting/strand (at end of Hababouk stage))]×100

Khalal fruits drop (%) = [(Number of fruits setting/strand (at start of Khalal stage))] - (retained fruit at harvest time)] / [(Number of fruits setting/strand (at end of Hababouk stage))] × 100.

Fruit Retention (%) = (Number of fruits at harvest per strand / Number of setting fruits per strand) × 100.

2.1.2. Yield /palm (Kg/palm)

During the harvest period (October month) in both seasons, the fruits of date palm bunches were weighted and used to obtain the total yield/palm by Kg.

2.2. Fruit physical characteristics at the harvest time

Fruit samples collected at full red color stage (Khalal) during the first week of October in both seasons. Forty fruits were randomly taken from all bunches of each palm for measurements of the physical and chemical characteristics including fruit weight (g) and size (cm^3), flesh weight (g) and seed weight (g).

2.3. Fruit chemical characteristics at the harvest time

2.3.1. Total anthocyanin content (mg\100g)

Certain weight (0.1 g) of fresh fruits skin was taken then immersed in 10 ml of methanolic HCl (900

ml absolute methanol + 10 ml concentrated HCl + 90 ml distilled water) and maintained in darkness bottle for 48 hours. The absorbance of this extract was measured at 532 nm using spectrophotometer Visible Spectrophotometer Machin NEUUV08). The concentration of total anthocyanin content in the extract was expressed as mg/100 g of fruit peel (Rabino et al., (1977) by using the following equation: Anthocyanin (mg/100g) = [(extraction solution volume × optical density) / (sample weight × 98.2 (E)) ×100]. The (E) value for 1 % solution at 530 nm is equal to 98.2.

2.3.2. Total soluble solid (TSS) %

It has been determined in fruit juice by using Carl-Zeiss hand refractometer according to A.O.A.C (2014).

2.3.3. Titratable acidity (TA) (%)

It was determined by titrating a 1.0 ml juice sample with 0.01 N sodium hydroxide (NaOH), using phenolphthalein (phph) as an indicator. The acidity was expressed as a gram of malic acid in 100 ml juice according to the method described in A.O.A.C (2014).

2.3.4. Ascorbic acid (AsA) content

Ascorbic acid content in fruit juice was determined according to the procedure described by Ranganna (1979) through the oxidation of ascorbic acid with 2,6 Dichlorophenolindophenol dye and the results were expressed as mg/100 ml juice.

2.3.5. Total soluble sugars content

It was determined in fruit flesh by the method described by Dubois et al. (1956) in 70% ethanol extract using the phenol sulfuric acid method. The total sugars percentage in the sample solution was calculated using the standard curve of different concentrations of glucose solution. The concentration was calculated and expressed as percentage of dry weight.

2.4. Rutability index of dates on room temperature (25±2ºC & 75% RH)

To study the effect of the tested spray treatments on the rutability behavior of healthy, flawless red fruits. The fruits were placed in 3 transparent perforated plastic bags for each treatment (20 fruits per bag as a replicate), then packed into cartons and placed under room conditions for 6 days. The number of rutabed fruits for all treatments was recorded at intervals of every two days. The rutability index was calculated according to the equation of Bench et al., (1991) with some modification. Rutability Index (RI) = (10 x n1) + (9 x n2) + … + (1 x n10) where n1, n2 … n10 = No. of rutab fruits on the first, second and subsequent days, respectively. In the RI, maximum value is given to the rutab fruits on the first day and less to those rutabed later. The lowest value would be for fruit rutabed on the 10th day. Therefore, the RI emphasizes both the percentage of rutability and its speed. A higher RI value denotes a higher percentage and rate of rutability.

2.5. Statistical Analysis

The variance between the means of tested treatments and the control were tested in randomized complete block design according to method substantive by Snedecor and Cochran (1989). The gained data from both seasons were subject to analysis of variance (ANOVA) using a Computer Software program called CoStat. The treatment means were compared by using Duncan's multiple range tests at probability of 0.05 according to Duncan (1965).

3. Results and discussion

The date palm cultivar 'Hayany' experiences severe fruit drops throughout the season, with maximum drop occurring during the "Hababouk" and "Khalal" stages. Its short shelf life and small size limit its marketing appeal. Improving quality and prolonging the khalal stage could expand its marketing potential.

The obtained results from the present study for two growing seasons 2019 and 2020 are recorded and illustrated in several Tables and Figures, for study and discussion the effect of spraying NAA, putrescine (Put), salicylic acid (SA) and Aspartic acid (Asp) on reducing fruit dropping and improving fruit quality of 'Hayany' dates before and during cold storage. This was accomplished through various parameters on fruits drop and yield, fruit physical characteristics and physiological and biochemical parameters in the current study were shown and discussed as follows:

3.1. Fruit drop percentage along growth season till harvest

The data recorded in Table 1 and Fig. 1 show the effect of spraying with growth regulators and aspartic amino acid on the drop of 'Hayany' date fruits in the two stages of Kimri and Bisr as the following:

Treatment with putrescine reduced the rate of drop during the different stages, as well increased fruit retention, where there are significant differences between putrescine and the control, as well as the other treatments. This finding is consistent with the results of Tavakoli and Rahemi (2014), who indicated that polyamine-treated fruit produced more fruit than untreated fruit of date palm.

It turned out that the aspartic acid caused a significant increase in the rate of fruit drop in the kimri and bisr stages during the two seasons, as well as decreased fruit retention, as there were significant differences between the aspartic treatment and both the control and the other of treatments. The results showed also that the combined treatment between salicylic and aspartic induced a reduction in the rate of drop fruits, especially in the Bisr stage Thus, there was

a significant difference between this treatment and the control as well as the other treatments. While there are no significant differences between it and the putrescine treatment. The results also showed that there are no significant differences between the other treatments and the control on the drop rate during the stages of fruit growth. The results in Table 5 revealed significantly higher correlation between total fruit drops and kimri drops (r=0.932) than bisr drop (r=0.913) (Table 5). This is consistent with result of Abd El-Kader et al. (2008) they observed an increase in the percentage of fruit drops on 'Zaghloul' date palms by foliar applying of NAA, and that the effect of increasing was concentration dependent, the NAA treatment at 20 ppm was close to control in both seasons.

From these results, it is possible to use putrescine to increase the fruit set rate and preserve the fruits from dropping during the kimri and bisir stages. On the other hand, aspartic acid can be used in the process of chemically thinning fruits, as it works to increase the rate of drop during the fruiting and ripening stages. Polyamines such as "putrescine" are well- known regulators of growth and differentiation (Bagni and Torrigini, 1992), and compete directly with ethylene for their common precursor S-adenosy-L-methionine (SAM) (Valero et al., 2002, b).

Table 1. Effect of spraying some growth regulators and amino compounds on fruit drop, retention, and yield of 'Hayany' date palm during 2019 and 2020 seasons

Spraying treatments	Fruit drop (%) at Kimri stage		Fruit drop (%) at Bisr stage		Retention fruit (%)		Yield/palm (kg)	
	Season							
	2019	2020	2019	2020	2019	2020	2019	2020
Water only (Control)	17.42b	18.99bcd	10.61b	7.82bc	71.97c	73.19bc	174.25d	187.84cd
0.5 mM Naphthalene acetic acid (NAA)	26.62a	20.10bcd	4.09bc	3.15bc	69.29c	76.75b	193.04bc	212.90b
2.5 mM Salicylic acid (SA)	16.42b	17.47cd	3.87c	9.13b	79.71b	73.40bc	182.18cd	204.89bc
1 mM aspartic acid (ASP)	29.95a	30.13a	17.75a	15.48a	52.30e	54.39d	134.94f	148.25e
1 mM putrescine (PUT)	7.09c	9.63e	7.01bc	5.36bc	85.90a	85.01a	245.84a	268.62a
0.5 mM NAA + 2.5 mM SA	14.57b	23.0abc	8.39bc	5.18bc	77.04b	71.82bc	155.36e	174.76d
0.5 mM NAA + 1 mM ASP	27.73a	25.67ab	10.68b	6.32bc	61.59d	68.01c	155.41e	186.14d
2.5 mM SA + 1 mM ASP	12.59bc	12.27de	1.89c	1.92c	85.52a	85.81a	201.03b	208.71b

Means followed by the same letter (s) in the same column don't significantly differ at 0.05 of probability according to Duncan's Multiple Range Test.

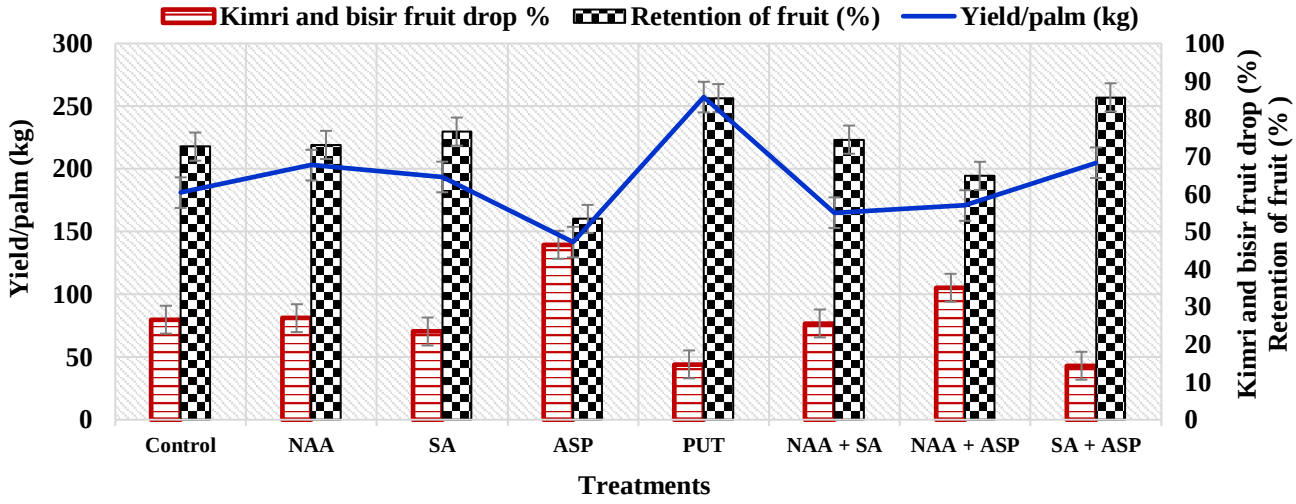

Fig. 1. Effect of spraying treatments of Naphthalene acetic acid (NAA), Salicylic acid (SA), putrescine (PUT) and their combination on kimri and bisir fruit drop%, fruit retention% and yield/palm (kg). Each value of two season average represents the mean ±SE of three replicates.

3.2. Yield/palm at harvest time

The results in Table 1 and Fig. 1 showed the effect of spraying with some growth regulators and aspartic amino acid on the yield of palm tree (kg)

The results demonstrated that spraying with putrescine at a concentration of 1 mmol gave the highest palm yield and was significantly superior to the control and other studied treatments. Similar results were detected by Hagagg et al. (2020), putrescine at 15 ppm was applied throughout the course of the two seasons to produce the highest yield of olive fruits, also agrees with Ahmed et al. (2014) and El-Badawy (2019). They found that applying amino acids produced the heaviest fruits and the highest yield on El-Saidy date palms and Canino apricot respectively.

In addition, spraying with naphthalene acetic acid at a concentration of 0.5 mmol resulted in a considerable increase in palm tree yield (kg) compared to the control. These findings are analogous to those of Harhash and Al-Obeid (2007), Nawaz et al. (2011) and Jasim et al. (2018), they found that for Barhee, shahl date palm cultivars and Kinnow mandarin, foliar application of naphthalene acetic acid (NAA) at different concentrations considerably increased overall yields compared to controls.

On the other hand, spraying with aspartic amino acid at a concentration of 1 mmol induced a significant reduction in palm yield compared to the control and the other the studied treatments, since it produced the lowest yield over the study's two seasons (148.25–134.94 kg/palm) for the palm tree respectively. The reduction in palm yield may be attributed to the increase in the percentage of fruits drops. Unlike Abdelaziz et al. (2021), who found that applying aspartic acids at 250 ppm alone or in combination with vitamin B complex in superior grapevines significantly improved yield in weight, bunch number, and dimensions. It was noted that the effect on palm yield varies depending on the interaction treatments between growth regulators and aspartic amino acid, as the spraying treatment containing salicylic acid and naphthalene acetic acid led to a significant decrease in palm yield compared with spraying with any of them alone, while the interaction treatment including aspartic acid and naphthalene acetic acid induced an increase in palm yield compared to spraying with aspartic amino acid alone.

The combination treatment containing aspartic acid and salicylic acid was significantly superior in date palm yield compared to both the control and spraying with aspartic amino acid alone. Such result may be referred to effect of SA on a range of diverse physiological processes in plants such as, photosynthesis, ethylene biosynthesis, fruit yield and quality, where previous studies demonstrated that foliar spraying of SA increased fruits yield (El-Tayeb, 2005 and Yildirim et al., 2008)

The obtained results cleared that spraying with any of the naphthalene acetic acid, putrescine, or the combination between aspartic acid and salicylic acid led to an improvement in the date palm yield compared to the control.

3.3. Effect of various growth regulators and amino acids spraying treatments on fruit physical properties at the harvest

The effects of some growth regulators and amino compounds on the physical characteristics of date fruits were recorded in Table 2.

The results showed that spraying with putrescine at 1 mmol improved the fruit weight, fruit flesh weight, fruit size, and seed weight compared to the control and most of the other tested treatments, respectively, in the two seasons These findings correspond with Ahmed et al. (2014) who found that applying amino acids at 0.1% to El-Saidy date palms boosted weight, dimensions, pulp %, and pulp/seed ratio comparing to non-application. Amino acids are responsible for enhancing the biosynthesis of proteins, and natural hormones such as IAA and ethylene and stimulating cell division (Kewade et al., 2023). Also agrees with Hagagg et al. (2020) who indicated that spraying different concentrations of putrescine on olive trees led to significant increases in fruit weight and pulp weight compared to the control.

The combined treatment between aspartic acid and naphthalene acetic acid induced a reduction in the weight and size of the fruit, as well as the weight of the fruit flesh, compared to the control, especially in the first season of the study. It was noted that both spraying treatments with naphthalene acetic acid or salicylic acid, alone or combination, did not produce significant differences in the studied physical characteristics of the fruits compared to the control. These findings correspond to some extent with Ahmed et al. (2022) they found that application of chitosan (Ch), calcium chloride (Ca) and salicylic acid (SA) on 'Khenizi' date palm decreased the fruits weight, length, and width comparing with the control.

Table 2. Effect of spraying some growth regulators and amino compounds on fruit physical properties of 'Hayany' date palm at harvest time during 2019 and 2020 seasons

Spraying treatments	Fruit weight (g)		Flesh fruit weight (g)		Fruit size (cm^3)		Seed weight (g)	
	Season							
	2019	2020	2019	2020	2019	2020	2019	2020
Water only (Control)	21.06a	18.23bc	18.64ab	16.15bc	22.15c	17.62bc	2.39abc	2.02c
0.5 mM Naphthalene acetic acid (NAA)	18.39b	19.65ab	16.32c	17.28a	21.15c	19.27ab	2.02c	2.36abc
2.5 mM Salicylic acid (SA)	22.12a	18.27bc	19.73a	15.79c	25.30a	17.97abc	2.33abc	2.27bc
1 mM aspartic acid (ASP)	21.04a	16.82c	18.29b	14.83d	23.41b	16.03d	2.70a	2.09c
1 mM putrescine (PUT)	21.25a	19.81a	18.73ab	17.60a	24.04b	19.77a	2.48ab	2.28bc
0.5 mM NAA + 2.5 mM SA	20.93a	19.57ab	18.44ab	17.06ab	23.78b	18.97ab	2.40abc	2.47a
0.5 mM NAA + 1 mM ASP	18.78b	18.21bc	16.62c	16.10bc	18.47d	17.67bc	2.16bc	2.10c
2.5 mM SA + 1 mM ASP	18.94b	19.11ab	16.45c	16.96ab	21.89c	18.90ab	2.37abc	2.15bc

Means followed by the same letter (s) in the same column don't significantly differ at 0.05 of probability according to Duncan's Multiple Range Test.

3.4. biochemical characteristics of date fruits at the harvest time

The data in Table 3 showed the effects of spraying with growth regulators and aspartic amino acid on the biochemical properties of date fruits at harvest.

Regarding the anthocyanin content in the fruit peel of 'Hayany' dates at harvest, all of the tested treatments, which include spraying with naphthalene acetic acid, salicylic acid, and aspartic acid alone or in combination and also spraying with putrescine, induced a significant reduction in the anthocyanin content of the fruit peels compared to the control. This can be explained by the fact that the treatments caused a delay in fruit ripening compared to the control, which had the highest values for anthocyanins in both seasons of the study.

Table 3. Effect of spraying some growth regulators and amino compounds on biochemical characteristics of 'Hayany' date palm fruits at harvest time during 2019 and 2020 seasons

Spraying treatments	Total anthocyanin content (mg/100g)		Titratable acidity (%)		Total soluble solid (%)		Total soluble sugars (%)		Ascorbic acid (mg/100ml juice)	
	Season									
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Water only (Control)	22.02a	20.84a	0.860a	0.806a	28.53c	26.93b	31.12bc	32.07bc	4.63c	7.73d
0.5 mM Naphthalene acetic acid (NAA)	16.17cd	15.56bc	0.581c	0.503d	26.66d	24.40d	20.94e	23.39f	5.60bc	8.64bc
2.5 mM Salicylic acid (SA)	17.41b	16.06b	0.603bc	0.659b	29.10b	26.40bc	26.05d	28.00de	6.20b	8.44bcd
1 mM aspartic acid (ASP)	17.07bc	14.77bc	0.670b	0.614bc	29.53a	28.40a	30.42bc	32.39bc	8.40a	10.37a
1 mM putrescine (PUT)	16.18cd	15.44bc	0.637bc	0.614bc	29.80a	26.27bc	29.63c	30.63bc	7.00ab	9.25ab
0.5 mM NAA + 2.5 mM SA	15.86d	13.95c	0.581c	0.480d	24.67e	22.53e	32.54b	33.67b	7.00ab	8.77bc
0.5 mM NAA + 1 mM ASP	11.95e	10.87d	0.603bc	0.525cd	25.60d	25.73cd	39.17a	38.17a	8.00a	8.87b
2.5 mM SA + 1 mM ASP	17.01bc	15.21bc	0.670b	0.547cd	26.00d	24.93d	24.01d	25.54e	6.40b	7.95cd

Means followed by the same letter (s) in the same column don't significantly differ at 0.05 of probability according to Duncan's Multiple Range Test.

It is also noted in Table 3 that the combination treatment between the salicylic acid and naphthalene acetic acid was exhibited the highest delay for fruit ripening, as it gave the lowest content of anthocyanins in the fruit peel. It was also noted that spraying with naphthalene acetic acid alone or in combination with salicylic acid and aspartic acid boosted the same trend as for anthocyanin content in fruit peel compared to the control and other treatments.

The same trend was observed in the effect of treatments on the titratable acidity of dates palm at harvest time, where the highest percentage of acidity was detected in the control treatment with an average 0.83% and the lowest value was obtained by the naphthalene acetic acid treatment alone or combined with salicylic acid or aspartic amino acid, with an average of (0.48-0.69%), (0.84-0.60 %), respectively

The results also showed that the highest content of total soluble solids was detected from spraying with aspartic acid, followed by spraying with putrescine and the untreated (control) treatment. While the fruits resulting from spraying with naphthalene acetic acid or its combination with salicylic acid or aspartic acid showed a significant reduction total soluble solid compared to the control and other treatments, except for the combination of salicylic acid with aspartic acid. The present data revealed significant positive correlation between TSS and titratable acidity (r= 0.638) (Table 5).

The obtained results are consistent with Jasim et al. (2018), where the control and salicylic acid treatments recorded the highest percentage of fruits acidity in the Barhee date palms. Also, Aboutalebi and Mohammadi (2015) reported that when treated Zahedi cultivar of date palm by naphthalene acetic acid resulted in considerably reduced TSS compared to the control.

As for the effect of spraying with growth regulators and aspartic acid on the soluble sugars content of fruits (Table 3), the results showed that the combination treatment of NAA plus aspartic acid showed a significant increase in the soluble sugars content of fruits compared to the control or applying any of them individually. Otherwise, spraying either NAA or salicylic acid alone gave significantly lower values of the soluble sugars content compared to the combination of them and the control. The results indicated a highly significant correlation between Total soluble sugar and the yield per palm (r= - 0.356) and bisri drops (r=0.458) (Table 5). These findings are in the same line with results of Abd El-Kader et al., (2008) who reported that total soluble solids and sugar content in 'Zaghloul' dates were significantly higher under spraying NAA at 40 or 50 ppm on 'Zaghloul' date bunches after two weeks from pollination time comparing to the control. Also, results of Wang et al., (2018) indicated that 10 mg/L naphthalene acetic acid (NAA) can obviously improve the fruit soluble solid and the content of sugar in Ziziphus jujube fruits.

Regarding the effect of spraying with growth regulators and aspartic acid on the ascorbic acid

content of fruits, the results demonstrated that all the studied treatments induced a significant increase in the ascorbic acid content of fruits compared to the control, and the highest content was detected by spraying with aspartic acid. These findings are congruent with Nawaz et al. (2008), who reported that using NAA treatment significantly increased ascorbic acid on Kinnow mandarin trees. As reported by Asadi et al. (2013) polyamines may increase vitamin C (ascorbic acid) content. Ascorbic acid content showed a highly negative correlation with fruit weight (r=0.465), fruit volume (r=0.616), and TA (r=0.95) and highly positive correlation with total fruit drops (r=0.380) (Table 5). Karlidag et al. (2009) reported that salicylic acid (SA) treatments positively affect ascorbic acid (AA) content in strawberry fruits.

Looking at the results regarding the chemical contents of the fruits at harvest time, the treatments spraying with naphthalene acetic acid alone or combined with salicylic acid or aspartic acid led to a delay in the ripening of the fruits compared to the control and other treatments, which is represented by a reduction in the fruit content of anthocyanins, acidity, and total soluble solids. It is like the results of Amiri et al. (2021) use of salicylic acid in maintaining postharvest quality and prolonging the shelf life of oranges. And Tavakoli and Rahemi (2014) found that polyamines reduced TSS and delayed fruit maturity by at least 17 days on dates palm.

3.5. Rutability index (RI) of the fruits on the room condition (25±2ºC & 75% RH)

The results of effect of some growth regulators and aspartic amino acid on the rutability behavior of healthy, flawless red fruits at intervals of every two days during 6-days shelf-life period on the room condition were recorded in Table 4.

All the studied treatments except spraying with salicylic acid at a concentration of 2.5 mM (Table 4) led to a significant reduction in the percentage of fruit rutability compared to the control during all studied shelf-life periods. Both of control treatment and spraying with salicylic acid alone (SA) produced the highest percentages of fruit rutability, the control treatment recorded 24.6, 37.1 and 40.8%, while SA recorded 22.1, 34.6 and 43.8% after 2, 4 and 6 shelf-life days, respectively. A higher RI value denotes a higher percentage and rate of rutability.

The two spraying treatments with aspartic acid or putrescine at a concentration of 1.0 mM achieved intermediate percentages of fruit rutability between the control and spraying with salicylic alone and the other tested treatments. The spraying treatment with aspartic acid recorded average percentages of fruit rutability of 13.8, 21.5 and 35%, while spraying with putrescine recorded 7.9, 20.0 and 35.4 after 2, 4 and 6 Shelf-life days, respectively.

Table 4. Effect of spraying some growth regulators and amino compounds on the rutability behavior of 'Hayany' date palm fruits at 3 periods of shelf life on the room condition during 2019 and 2020 seasons

Spraying treatments	Fruit rutability %						Rutability index	
	Intervals of shelf life (days)							
	2		4		6			
	Season							
	2019	2020	2019	2020	2019	2020	2019	2020
Water only (Control)	30.0a	19.7a	48.3a	25.8a	51.7a	30.0b	109.3a	64.5a
0.5 mM Naphthalene acetic acid (NAA)	8.3cd	4.7d	11.7d	6.7c	15.0d	8.3e	28.0e	15.7d
2.5 mM Salicylic acid (SA)	23.3ab	20.8a	36.7b	32.5a	50.0a	37.5a	93.0b	66.3a
1 mM aspartic acid (ASP)	16.7bc	10.8b	25.0bc	16.7b	46.7ab	30.0b	83.0bc	62.6a
1 mM putrescine (PUT)	8.3cd	7.5bc	25.0bc	15.0b	43.3b	27.5b	76.0c	46.2b
0.5 mM NAA + 2.5 mM SA	6.7cd	3.3d	11.7d	8.3c	16.7d	13.3d	27.3e	19.5d
0.5 mM NAA + 1 mM ASP	6.7cd	8.3bc	15.0cd	16.7b	25.0c	22.5c	44.3d	33.7c
2.5 mM SA + 1 mM ASP	5.0d	9.7bc	18.3cd	26.7a	25.0c	30.0b	47.3d	52.0b

Means followed by the same letter (s) in the same column don't significantly differ at 0.05 of probability according to Duncan's Multiple Range Test.

On the other side. The results in Table 4 showed that the spray treatment with NAA at a concentration of 0.5 mmol alone or in combination with salicylic acid or aspartic acid caused significantly lower percentages of fruit rutability compared to the control and most of the other tested treatments. The spray treatment with NAA alone recorded the lowest percentages of fruit rutability, especially after 4 and 6 days of shelf life (8.7 and 11.7%, respectively). Such result agreed with Al-Qurashi and Awad (2011), they reported that the application of NAA on 'Barhee' date palm significantly decreased fruit ripening, as measured by rutab percentage, compared to control.

Regarding the rutability index, the control treatment was significantly superior to all the studied treatments except for spraying with salicylic acid alone, where it recorded an average rutability index of 86.5. On the contrary, the spray treatment with NAA alone or in combination with salicylic acid led to a significant reduction in the rutability index (21.8% and 23.4%, respectively) compared to the other studied treatments. Rutability index showed high significant positive correlation with TSS r=0.71), TA (0.64) and fruit weight (0.830) (Table 5).

Table 5. The personal correlations between the different variables of 'Hayany' dates palm as affected by spraying with some growth regulators and amino compounds at harvest time in both 2019 and 2020 seasons

	Kimri Drop	Bisr Drop	Total Drop	Retention Fruit	Yield/ palm	Fruit Weight	Flesh Weight	Seed Weight	Fruit Volume	Anthocy anins	TA	TSS	Total sugars	Ascorbic Acid	Rutab 2 Day	Rutab 4 Day	Rutab6 Day	Rutability Index
Kimr iDrop																		
Bisr Drop	.555**																	
Total Drop	.932**	.819**																
RetentionFruit	-.920**	-.804**	-.985**															
Yield/palm	-.713**	-.577**	-.744**	.763**														
Free-weight	-.382**	-.049	-.285*	.293*	.071													
Flesh Weight	-.398**	-.087	-.313*	.313*	.096	.972**												
Seed Weight	-.117	.111	-.032	.063	-.059	.554**	.343*											
Fruit Volume	-.364*	-.076	-.284	.288*	.023	.861**	.853**	.419**										
anthocyanins	-.273	.097	-.146	.163	.024	.295*	.299*	.120	.344*									
Acidity	-.137	.270	.023	-.034	-.190	.333*	.336*	.138	.477**	.610**								
TSS	-.004	.387**	.166	-.177	-.084	.184	.207	-.001	.384**	.341*	.638**							
Total sugars	.299*	.458**	.406**	-.411**	-.356*	-.120	-.126	-.037	-.301*	-.337*	-.027	-.062						
Ascorbic Acid	.384**	.282	.388**	-.382**	-.135	-.465**	-.486**	-.138	-.616**	-.501**	-.595**	-.343*	.345*					
Rutab2Day	.003	.300*	.133	-.140	-.189	.237	.270	-.010	.196	.570**	.583**	.509**	-.026	-.299*				
Rutab4Day	-.225	.173	-.080	.082	-.026	.319*	.352*	.029	.283	.587**	.559**	.546**	-.064	-.366*	.875**			
Rutab6Day	-.179	.389**	.046	-.059	-.063	.425**	.443**	.128	.408**	.475**	.582**	.739**	.028	-.288*	.739**	.844**		
Rutability Index	-.149	.401**	.072	-.087	-.121	.383**	.400**	.112	.368*	.578**	.642**	.731**	.004	-.340*	.788**	.865**	.970**	

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed).

4. Conclusions

From the previous results, it could be concluded that the 1 mM putrescine treatment reduced the rate of fruit drops, especially in the kimri stage, produced the highest fruit retention, palm yield and induced an improvement in the average fruit weight, fruit flesh weight, fruit size, and seed weight compared to the control and most of the other tested treatments. On contrary, 1 mM aspartic acid significantly increased the fruit drops in the kimri and bisr stages, a significantly reduction in palm yield and induced the highest content of total soluble solids compared to both the control and the other of treatments. Applying 0.5 mM naphthalene acetic acid alone or in combination with 2.5 mM salicylic acid or 1 mM aspartic acid led to a delay in fruit ripening compared to the control and other treatments. In addition, spraying with 0.5 mM Naphthalene acetic acid alone or in combination with 2.5 mM salicylic acid delayed rutability percentage compared to control and other treatments and these treatments helps in prolonging the marketing season of 'Hayany' dates.

5. References

O. A. C. (2014). Official Methods of Analysis. 49th. Association of Official Agricultural Chemists. Washington. D.C., U.S.A.

Abdelaziz, F.H., Ahmed, F.F., Abdel Aal, A.M.K., Masoud, A.A.B. and Safwat-Manar, M. 2021. Effect of Spraying Some Amino Acids, Vitamin B and Boron on Yield and Berry Quality of Superior Grapevines. Int. J. Environ., 10(1): 25 -32.

Abd El-Kader, A. M.; El-Makhtou, F. B.; Aly, S.H. and El-Roby, K.A. (2008). Effect of naphthalene acetic acid (NAA) spray on yield and fruit characteristics of Zaghloul date palm. Alexandria Science Exchange Journal, 29 (4): 252-256.

Abd El-Razek, E.; Hassan, H.S.A. and Gamal El-Din, K.M. (2013). Effect of foliar application with salicylic acid, benzyladenine and gibberellic acid on flowering, yield and fruit quality of olive trees (*Olea europaea* L.). Middle-east journal of scientific research, 14(11): 1401-1406.

Abo Sedera, F. A.; Amany, A.L.; Abd El-Latif, A. A.; Bader, A. and Rezk, S.M. (2010). Effect of NPK mineral fertilizer levels and foliar application with humic and amino acids on yield and quality of strawberry. Egyp. J. Appl. Sci., 25: 154-169.

Aboutalebi, A. and Mohammadi, A. (2015). Evaluating the effects of 2, 4-D, naphthalene acetic acid and potassium nitrate on yield and fruit quality of date palm (Phoenix dactylifera) cv. Zahedi. International Journal of Biosciences (IJB), 6(1):192-200.

Ahmed, A.A. (1999). Date palm postharvest processing technology in Libya. Regional Workshop on Date Palm Postharvest Processing and Technology in Iran.

Ahmed, A.A. (2023). Yield and fruit quality of sewy date palm in response to foliar spray with silicon and salicylic acid. Assiut Journal of Agricultural Sciences, 54(1): 189-197.

Ahmed, A.H.H.; Darwish, E. and Alobaidy, M. G. (2017). Impact of putrescine and 24- epibrassinolide on growth, yield and chemical constituents of cotton (*Gossypium barbadense* L.) plant grown under drought stress conditions. Asian J. Plant Sci., 16(1):9–23.

Ahmed, F.F.; Ali, A.H. S.; Sayed, E.S. and Sayed-Ola, M.O. (2014). Using some amino acids enriched with certain nutrients for improving productivity of El-Saidy date palms. World Rural Observations, 6(2): 20-27.

Ahmed, Z.F.; Kaur, N.; Maqsood, S. and Schmeda-Hirschmann, G. (2022). Preharvest applications of chitosan, salicylic acid, and calcium chloride have a synergistic effect on quality and storability of date palm fruit (*Phoenix dactylifera* L.). HortScience, 57(3): 422-430.

Akladious, S.A. and Abbas, S.M. (2013). Alleviation of seawater stress on tomato by foliar application of aspartic acid and glutathione. Journal of Stress Physiology and Biochemistry, 9(3): 282-298.

Al-Khayri, J.M. (2001). Optimization of biotin and thiamine requirements for somatic embryogenesis of date palm (*Phoenix dactylifera* L.). In Vitro Cell. Dev. Biol. Plant, 37: 453-456.

Al-Qurashi, A.D. and M.A. Awad. 2011. Naphthaleneacetic acid increase bunch weight and improve fruit quality of 'Barhee' date palm cultivar under hot arid climate. American-Eurasian J. Agric. & Environ. Sci., 10(4): 569-573.

Amiri, S.; Nicknam, Z.; Radi, M.; Sayadi, M.; Bagheri, F.; Karimi Khorrami, N. and Abedi, E. (2021). Postharvest quality of orange fruit as influenced by salicylic acid, acetic acid, and carboxymethyl cellulose coating. Journal of Food Measurement and Characterization, 15(5): 3912-3930.

Asadi, S.; Ardebili, Z.O. and Abdossi, V. (2013). The modified fruit quality by the application of different kinds of polyamines in apricot tree (*Prunus armeniaca*). J. Appl. Environ. Biol. Sci., 3(1): 28-31.

Awad, M.A., 2007. Increasing the rate of ripening of date palm fruit (Phoenix dactylifera L.) c.v. "Helali" by preharvest and postharvest treatments. Postharvest Biol. Technol., 43(1):121-127.

Bagni, N and P. Torrigiani. (1992). Polyamines: a new class of growth substances. In: Karssen C. M.; L. C. Van loon and D. Vreugdenhil (eds) Progress in Plant Growth Regulation. Kluwer Academic Publishers, Dordrecht, pp 264-275

Ben Salah, M. (2001). Study on fruit drop of Khenazy date palm cultivar. In: proceedings of the second international conference on date palms, United Arab Emirates University, Al-Ain. p. 161.

Bench, A.R.; Fenner, M. and Edwards, P. (1991). Changes in germinability, ABA content and ABA embryonic sensitivity in developing seeds of *Sorghum bicolor* (L.) Moench induced by water stress during grain filling. New Phytologist, 118: 339–347.

Dubois, M.; Gilles, K.A.; Hamilton, J.K.; Rebers. P.A. and Smith, F. 1956. Anal. Chem. 26: 350.

Duncan, D.B. (1965). Multiple range and multiple F-test. Biometrics, 11: 1-42.

El-Badawy, H.E.M. (2019). Effect of spraying amino acids and micronutrients as well as their combination on growth, yield, fruit quality and mineral content of canino apricot trees. Journal of Plant Production, 10(2): 125-132.

El-Badawy, H. E. M.; EL-Gioushy, S.F. and Ahmed, I.A.M. (2018). Effect of some thinning practices on yield and fruit quality of Sewi date palm grown in Farafra region. Asian Journal of Agricultural and Horticultural Research, 2(3): 1-20.

El-Dengawy, E.F.A.; Samaan, L. G.; El-Shobaky, M.A.; El-Kadi, S. M. and Saleh, M.A.A. (2018). Evaluation of rutability, quality and microbial load in hayani date palm fruits during cold storage as affected by applying some safe postharvest treatments. Journal of Plant Production, 9(10): 805-813.

El-Salhy, A.M. (2001). The relation between leaf/bunch ratio and Zaghloul date productivity. Egypt J. Hort., 28: 149-15.

El-Sayed, R. and Habasy, Y. (2015). Effect of spraying salicylic acid on fruiting of valencia orange trees. Alexandria Journal of Agricultural Sciences, 60(3): 119-126.

El-Tayeb, M.A. 2005. Response of barley grains to the interactive effect of salinity and salicylic acid. Plant Growth Regulation 45:215-224.

FAO. (2021). Food and agriculture organization of the united nation. Statistics of food and agriculture organization of the United Nations. http://www.fao.org.

Hagagg, L.F.; Abd-Alhamid, N.; Hassan, H. S.; Hassan, A.M. and Geanidy, E.A. (2020). Influence of foliar application with putrescine, salicylic, and ascorbic acid on the productivity and physical and chemical fruit properties of Picual olive trees. Bulletin of the National Research Centre, 44: 1-11.

Harhash, M.M. and Al-Obeed, R.S. (2007). Effect of naphthalene acetic acid on yield and fruit quality of barhee and shahl date palm cultivars. Assiut Journal of Agricultural Sciences, 38(1): 63-73.

Jasim, A.F.; Hassan, A.S.A.; Al-Ashkar, R. A. and Gad, M. M. (2018). Effect of spraying some growth regulators; salicylic acid; calcium and boron on yield and fruit quality of barhee date palms. Zagazig Journal of Agricultural Research, 45(1): 65-73.

Karlidag, H.; Yildirim, E. and Turan, M. (2009). Exogenous applications of salicylic acid affect quality and yield of strawberry grown under anti frost heated greenhouse conditions. Journal of Plant Nutrition and Soil Science, 172(2): 270-276.

Kawade, K., Tabeta, H., Ferjani, A. and Hirai, M.Y., 2023. The Roles of Functional Amino Acids in Plant Growth and Development. Plant and Cell Physiology 64(12):1482–1493.

Khademi, Z. and Ershadi, A. (2013). Postharvest application of salicylic acid improves storability of peach (*Prunus persica* cv. Elberta) Fruits.

International Journal of Agriculture and Crop Sciences, 5(6): 651.

Khan, M.I.R.; Syeed, S.; Nazar, R. and Anjum, N.A. (2012). An insight into the role of salicylic acid and jasmonic acid in salt stress tolerance. In: Khan, N.A.; Nazar, R.; Iqbal, N. and Anjum, N.A. (eds), Phytohormones and Abiotic Stress Tolerance in Plants. Springer, Berlin, pp 277–300.

Li, J. and Yuan, R. (2008). NAA and ethylene regulate expression of genes related to ethylene biosynthesis, perception and cell wall degradation during fruit abscission and ripening in 'Delicious' apples. Journal of Plant Growth Regulator, 27: 283-295.

Maurya, P.K.; Tripathi, V.K. and Gupta, S. (2020). Effect of pre-harvest application of GA3, Naphthalene acetic acid and borax on fruit drop, yield and quality of Mango cv. Amrapali. Journal of Pharmacognosy and Phytochemistry, 9(6): 2123-2127.

Mohamed, S.A.; Awad, M.A. and Al-Qurashi, A.D. (2014). Antioxidant activity, antioxidant compounds, antioxidant and hydrolytic enzymes activities of 'Barhee' dates at harvest and during storage as affected by pre-harvest spray of some growth regulators. Scientia Hort., 167: 91–99.

Musselman, L.J. (2007). Figs, Dates, Laurel and Myrrh: plants of the bible and the quran. Timber Press, Inc., Portland, OR, pp. 114–119.

Nawaz, M.A.; Ahmad, W.; Ahmad, S. and Khan, M.M. (2008). Role of growth regulators on preharvest fruit drop, yield and quality in Kinnow mandarin. Pak. J. Bot., 40(5): 1971-1981.

Nawaz, M.A.; Afzal, M.; Ahmed, W.; Ashraf, M.; Jaime, A.; Teixeira, D. S.; Akhtar, N.; Shahzad, S. M.; Ullah, H. and Hussain, Z. (2011). Exogenous application of 2, dd, GA3 and NAA at flowering improves yield and quality of kinnow mandarin (*Citrus Reticulata* Blanco). The Asian and Australasian Journal of Plant Science and Biotechnology, 5: 17-21.

Rabino, I., Mancinelli, A.L. and Kuzmanoff, K.M. (1977). Photo control of anthocyanin synthesis .VL. Spectral sensitivity, irradiance dependence and reciprocity relationship. Plant Physiol., 59: 569 – 573.

Racskó, J.; Leite, G. B.; Petri, J.L.; Zhongfu, S.; Wang, Y.; Szabó, Z.; Soltész, M. and Nyéki, J. (2007). Fruit drop: The role of inner agents and environmental factors in the drop of flowers and fruits. Int. J. Hortic. Sci., 13: 13–23.

Ranganna, S. (1979). Manual of Analysis of Fruit and Vegetable Products. 2nd Ed. Tata McGraw. Hill, publishing company Limited, New Delhi, pp. 634.

Robinson, T.; Hoying, S.; Iungerman, K. and Kviklys, D. (2010). Retain combined with NAA controls pre-harvest drop of McIntosh apples better than either chemical alone. New York Fruit Quart, 18(3): 9-13.

Snedecor, G.W. and Cochran, W.G. (1989). Statistical Methods. 7th Ed., Iowa State Univ. Press Ames. Iowa, U.S.A., pp: 593.

Tavakoli, K. and Rahemi, M. (2014). Effect of polyamines, 2, 4-D, isopropyl ester and naphthalene acetamide on improving fruit yield and quality of date (Phoenix dactylifera L.). International Journal of Horticultural Science and Technology, 1(2): 163-169.

Valero, D.; D. Martinez-Romero and M. Serrano. (2002). The role of polyamines in the improvement of the shelf life of fruit. Trends in Food Science & Technology., 13:228-234.

Wang, Y.; Tao, T.; Liao, P. and Deng, Q. (2018). Effects of GA3, NAA and PCPA on the fruit drop rate and quality of Ziziphus jujuba 'Zhanshanmizao'. In: 7th International Conference on Energy and Environmental Protection. Advances in Engineering Research, 170: 1406-1409.

Wood, B.W. (2011). Influence of aminoethoxyvinylglycine (AVG) on yield and quality of nut crops from a commercial pecan orchard. HortScience, 46: 586–589.

Xu, M.; Yuan, L.; Li, W.; Li, Y. T.; Li, J. and Zhao, B.Q. (2018). Effects of a fertilizer synergist containing compound amino acids on seed germination and seedling growth of pakchoi under NaCl stress. J. Plant Nutr. Fert., 24(4): 992–1000.

Yildirim, E., E. Turan, and M. Guvenc. 2008. Effect of foliar salicylic acid application on growth, chlorophyll and mineral content of cucumber grown under salt stress. J. Plant Nutr. 31:593-612.

Yuan, R. and Li, J. (2008). Effect of sprayable 1-MCP, AVG and NAA on ethylene biosynthesis, preharvest fruit drop, fruit maturity and quality of 'Delicious' apples. American Society for Horticultural Science, 43: 1454-146.