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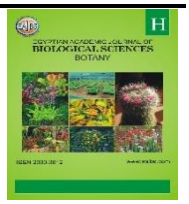

Impact of Some Preharvest Treatments on Fruit Size and Quality of "African Rose" Plums

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ABSTRACT

This study was carried out during the two seasons 2020 and 2021 on five years old "African Rose" plum (*Prunus salicina* L.) budded on Nemaguard rootstock, grown in a sandy soil under drip irrigation system under El-Nubaria, EL-Beheira Governorate, enhance the fruit size and quality of "African Rose" plums, using at least of these treatments were; T_1- Control, T_2- 20 ppm TDZ, T_3- 30 ppm TDZ, T_4- 0.5 ppm Br, T_5- 1 ppm Br, T_6-0.5% KNO_3, T_7-1% KNO_3, T_8-20 ppm TDZ and 0.5 ppm Br, T_9- 20 ppm TDZ and 0.5% KNO_3, T_{10}- 20 ppm TDZ, 0.5 ppm Br and 0.5% KNO_3, T_{11}- 30 ppm TDZ and 1 ppm Br, T_{12}- 30 ppm TDZ and 1% KNO_3 and T_{13}- 30 ppm TDZ, 1 ppm Br and 1% KNO_3.The experimental design was a randomized complete block design (RCBD) with five replicates. Results indicated that all foliar applications above treatments, significantly ($P \leq 0.05$) increased growth characters and number of fruits per tree as compared with the control during both seasons. Also, all treatments, significantly ($P \leq 0.05$) increased fruit weight(gm), yield (kg/tree), total yield (ton/feddan), anthocyanin and vitamin C as compared with the control treatment. Moreover, the application of 30 ppm TDZ+1 ppm Br +1% KNO_3 and 30 ppm TDZ+ 1 ppm Br treatments, significantly ($P \leq 0.05$) increased fruit size, length, diameter and firmness as compared with the others during both seasons. On the other hand, all K- nitrate and 30 ppm TDZ + 1 ppm Br +1% KNO_3 treatments, significantly ($P \leq 0.05$) increased total soluble solids (%), and total sugars but decreased fruit juice acidity (%) as compared to the control and the rest of the treatments during both seasons.

INTRODUCTION

Plum (*Prunus salicina* L.) is one of the deciduous fruit trees grown in Egypt. The plum is a member of Rosaceae family which is considered one of the most widely distributed deciduous fruit trees in the world (Hassan *et al*., 2021). The total area planted with plums in Egypt reached about 1115 hectares with a total annual production of 13,725 tons according to FAOSTAT (2021). Plum fruit has a great source of important nutritional properties that can benefit our health in many ways, it is high in fiber and rich in carbohydrates including sugar alcohol and soluble sugars like sucrose, glucose, and fructose. Additionally, it contains organic acids, fats, proteins, minerals, vitamins and antioxidant pigments (Kim *et al*., 2003; Crisosto, 2023).

Thidiazuron (TDZ) is a synthetic cytokinin, derived from phenyl urea, the main TDZ effect was achieved through a direct enhancement of fruit cell division (Choi *et al*.,2023). TDZ increased fruit size and yield of plums (Stern *et al.,* 2003 and Fagundes *et al.,* 2016). Thidiazuron triggers cytokinin responses in plants as successfully as natural cytokinins, no matter whether directly or indirectly. A direct TDZ effect is mediated through the activation of all the cytokinin receptors in plants and their downstream associated signaling pathways. The indirect effect of TDZ is its ability to inhibit the enzyme cytokinin oxidase/dehydrogenase which degrades cytokinins. This should lead to the elevation of endogenous cytokinin levels (Nisler, 2018).

Brassinosteroids (BRs) are a new class of steroidal plant hormones. They are of ubiquitous occurrence in the plant kingdom and are implicated in a wide range of physiological, biochemical and molecular responses in plants, such as seed germination, cell division and elongation, vascular differentiation, photomorphogenesis, photosynthesis, enzyme activation and senescence (Ali, 2017). BRs are polyhydroxylated compounds related to the structure of 5a - cholestane, a chemical structure like many organic compounds. The chemical class of BRs shares similar actions to steroids but acts in plants mostly via genetically mediated factors (Bishop and Yokota, 2001 and Mussing, 2005). One of the main sources of brassinosteroids is in pollens to induce growth.

Potassium nitrate is known to increase fruit size in several fruit crops (Al-Bamarny *et al*., 2010b). Potassium is one of the essential nutrients described as the quality element for fruit crop production. It was reported to improve fruit quality, fruit coloration, shipping quality and shelf-life (Lester *et al.,* 2007). Foliar spray of potassium nitrate could be attributed to enhancing the photosynthetic efficiency of leaves and a possible increase in translocation of assimilates into the fruits resulting in larger fruit size and also plays an important role in the interplay of metabolic events involved in fruit ripening and senescence (Vikramjeet and Kaur, 2018). Potassium (K) is involved in the quality-related characteristics of fruit (Ahmad *et al.,* 2018). Fruit size, appearance, color, soluble solids, acidity, vitamin content as well as taste are significantly influenced by an adequate supply of K (Jawandha *et al.,* 2017; Bibi *et al.,* 2019).

MATERIALS AND METHODS

This study was carried out during the two successive seasons 2020 and 2021 on five years old 'African Rose' plum plants budded on Nemaguard rootstock, spaced at 2 x 3 meters apart (700 tree/feddan) grown in a sandy soil under drip irrigation system in a private orchard located at El-Nubaria, EL-Beheira governorate, Egypt to enhance the fruit size and quality of "African Rose" plums.

Sixty-five uniform trees, free from various physiological and pathological disorders were selected for investigation during both successive seasons.
The treatments were as follows:

T_1- Control	T_6-0.5% KNO_3	T_{11}- 30 ppm TDZ and 1 ppm Br
T_2- 20 ppm TDZ	T_7-1% KNO_3	T_{12}- 30 ppm TDZ and 1% KNO_3
T_3- 30 ppm TDZ	T_8-20 ppm TDZ and 0.5 ppm Br	T_{13}- 30 ppm TDZ,1 ppm Br and 1% KNO_3
T_4- 0.5 ppm Br	T_9- 20 ppm TDZ and 0.5% KNO_3	
T_5- 1 ppm Br	T_{10}- 20 ppm TDZ, 0.5 ppm Br and 0.5% KNO_3	

Table 1: Some physical and chemical properties of the experimental soil.

Parameter	Soil depth (cm)	
	0 – 30	**30 – 60**
Mechanical analysis (%)		
Sand	93.3	92.2
Silt	3.9	4.3
Clay	2.8	3.5
Textural class	Sandy	Sandy
$CaCo_3$ (%)	5.2	4.1
Organic matter, (%)	0.45	0.25
Ph	8.27	8.30
EC (dS/m) Soil extraction 1:5	0.810	0.830
Available Nutrients, (mg/kg)		
N	115.5	116.5
P	18.0	17.5
K	410	200
Soluble cations, (meq/L)		
Ca^{++}	2.33	2.25
Mg^{++}	1.60	1.32
Na^{+}	3.68	3.44
K^{+}	1.47	1.41
Soluble Anions, (meq/L)		
HCO_3^{-}	3.12	3.03
CL^{-}	4.70	4.25
SO_4^{--}	2.18	2.52

Thidiazuron(TDZ) is a synthetic cytokinin, derived from phenylurea (1-Phenyl-3-(1,2,3-thiadiazol-5-yl) urea) by Sigma-Aldrich, brassinosteroids (BRs) are a new class of steroidal plant hormones (Brassinolide 80%) by Sigma-Aldrich and Potassium nitrate (KNO_3)is NK fertilizer containing nitrogen (13.7%) and potassium oxide (46.2%) produced by Vetra Agro-Science.

Thidiazuron and Brassinosteroids were applied during the stage of cell division after fruit thinning and before pit hardening (once) on March 24th, 2020 and March 29th, 2021 years. Potassium nitrate was sprayed twice, the first before pit hardening on March 24^{th,} 2020 and March 29^{th,} 2021 years, and the second during the beginning of the third stage of fruit growth on April 9th, 2020 and April 15th, 2021 years. Treatments are sprayed with the specified solutions till run off on trees.

The previous treatments were applied and arranged in a randomized complete block design. Each treatment included five replicates with one tree for each replicate. The effect of the previous treatments was investigated *by* evaluating their influence on the following parameters:

1. Vegetative Growth:

At the end of the growing season on the 1st of October, the selected shoots were measured for the average shoot length (cm), and shoot diameter (cm) using hand caliber and leaf area according to this formula, leaf area (cm^2) = 0.49 *(length of leaf × width of leaf) + 19.69 (Ahmed and Morsy,1999).

2. Yield:

The fruit yield on each replicate tree resulting from the applied treatments was expressed as the number of fruits per tree and the weight of fruits as kg per tree which was attained at the harvest stage on June 4th, 2020 and June 8th, 2021 years. Also, yield produced

as ton/feddan was expressed by multiplying the weight of fruits/tree by x number of trees/feddan.

3. Fruit Quality:

Samples of 20 fruits per tree from each replicate were collected randomly on June 4th, 2020, and June 8th, 2021 years and then transferred quickly to the laboratory to determine physical and chemical fruit characteristics. The fruit was harvested at commercial maturity when they reached the minimum standards for harvest with acceptable red skin and yellow pulp.

Physical fruit characteristics: Fruit samples were weighed and the average fruit weight for each replicate was calculated. Average fruit length (L) and diameter (D) were measured using a hand caliper to obtain fruit shape index (L/D) calculated mathematically as a ratio. Fruit firmness was expressed as ($lb/Inch^2$) according to Magness and Taylor (1982). Flesh firmness was measured on two opposite sides of the fruit using the Magness Taylor pressure.

Chemical fruit characteristics: Samples of 10 fruits were picked, randomly, at harvesting time to determine the following parameters: Total soluble solids of fruit juice (TSS %) using a hand refractometer according to Chen and Mellenthin (1981). Total acidity was determined in fruit juice according to AOAC (1985) using titration with 0.1N sodium hydroxide. Acidity was expressed as a percent of malic acid in fruit juice. Vitamin C (Ascorbic acid) was determined by titration with (2,6 dichlorophenyl -indo-phenol) on 5 ml of fresh juice using an acidic indicator (Egan *et al.,* 1987). Total sugars were determined in fresh fruit samples according to the procedure of Malik and Singh (1980). Anthocyanin content was determined at the stage of coloration (mg/100g fresh weight) according to Fuleki and Francis (1968).

Statistical Analysis:

Results of the measured parameters were subjected to computerized statistical analysis using COSTAT package for analysis of variance (ANOVA) and means of treatments were compared using LSD at 0.05 level of possibility according to Sendecor and Cochran (1980).

RESULTS AND DISCUSSION

The impact of ' African Rose Plum trees vegetative and reproductive growth (yield and fruit quality) to foliar application with thidiazuron brassinosteroids and potassium nitrate are presented in Tables (2-5).

1 Vegetative Growth Characters:

The results concerning the effect of studied foliar applications with thidiazuron, brassinosteroids and potassium nitrate treatments on vegetative growth characters of 'African Rose' Plum trees in both seasons are listed in Table (2). The average values of both experimental seasons indicated that all foliar application treatments, significantly ($P \leq 0.05$) increased vegetative growth characters as compared with the control during both seasons. Generally, foliar application with 30 ppm TDZ + 1 ppm Br +1% KNO_3 treatment; brought about the highest increment in vegetative growth characters, followed by 20 ppm TDZ + 0.5 ppm Br +0.5% KNO_3 treatments and 30 ppm TDZ + 1 ppm Br treatments as compared with the control during both seasons.

A gradual increase in shoot length was observed with trees treated with (30 ppm TDZ + 1 ppm Br + 1% KNO_3) treatment (83.50 and 83.40 cm, 2020 and 2021 seasons, respectively) and (20 ppm TDZ + 0.5 ppm Br +0.5% KNO_3) application (82.48 and 82.29 cm, serially), followed by (30 ppm TDZ + 1 ppm Br) treatment (73.45 and 73.72 cm, each in turn) then(20 ppm TDZ + 0.5 ppm Br) treatment (72.79 and 73.06 cm, serially) as compared with the control (54.14 and 55.18 cm, each in turn) in both seasons.

A gradual increase in shoot thickness was observed with trees treated with (30 ppm TDZ + 1 ppm Br +1% KNO_3), (0.75 and 0.76 cm, each in turn) and (20 ppm TDZ + 0.5 ppm Br +0.5% KNO_3) treatments (0.72 and 0.75 cm, serially), followed by (20 ppm TDZ + 0.5 ppm Br) application treatment (0.68 and 0.67 cm, each in turn) and 30 ppm TDZ + 1 ppm Br (0.65 and 0.67 cm, serially) as compared with the control (0.34 and 0.36 cm, each in turn) in both seasons.

Spraying the trees with (30 ppm TDZ + 1 ppm Br +1% KNO_3) and (30 ppm TDZ + 1 ppm Br) gave the highest leaf area (15.70 and 15.82 cm^2), (15.47 and 15.63 cm^2), respectively followed by (20 ppm TDZ + 0.5 ppm Br +0.5% KNO_3) treatments and (20 ppm TDZ + 0.5 ppm Br) treatments (14.64 and 14.58 cm^2), (14.36 and 14.42 cm^2), each in turn, as compared with the control treatment (11.43 and 11.51 cm^2).

The increment in the vegetative growth of the saplings derived from treatment with thidiazuron may be attributed to the role of cytokinines in promoting the growth of leaves primordia through cell division and differentiation (Davies, 1994), TDZ also influences the allocation of nutrients and assimilates in the plant towards treated tissues with it (Guo *et al*., 2011), these results are consistent with Al-Hameedawi (2016) when spraying the fig trees with the TDZ, significantly increased the vegetative growth. Brassinosteroids have a crucial role in regulating the growth and development processes of plants in a coordinated manner for providing energy and the building blocks that generate the form that is recognized as a plant, BRs are generating a significant impact on photosynthesis, transpiration, ion uptake and transport, besides specific changes in leaf anatomy and chloroplast structure. Plant growth is largely an outcome of photosynthetic apparatus and the building blocks synthesized through the uptake of essential nutrients, the efficiency of light energy transformation, and CO2 productivity (Sharma, 2021). The positive effect of potassium nitrate foliar could be attributed to enhancing the photosynthetic efficiency of leaves, activating a number of enzymes, including those involved in the synthesis of carbohydrates, and involved in the neutralization of organic acids and the promotion of normal cell division and growth Al- Bamarny *et al*. (2010a) and Vikramjeet and Kaur (2018).

Table 2: Growth parameters of "African Rose" Plums as affected by thidiazuron, brassinosteroids and potassium nitrate during both 2020 and 2021 seasons.

Treatments	Shoot length (cm)		Shoot thickness (cm)		Leaf area (cm^2)	
	2020	2021	2020	2021	2020	2021
T_1	54.14e	55.18e	0.34d	0.36d	11.43e	11.51e
T_2	64.50c	64.82c	0.65b	0.66b	12.61d	12.71d
T_3	66.14c	66.49c	0.66b	0.65b	13.19c	13.23c
T_4	61.49d	61.62d	0.53c	0.55c	11.88e	11.82e
T_5	61.10d	61.47d	0.54c	0.55c	12.53d	12.55d
T_6	60.49d	60.73d	0.55c	0.54c	11.80e	11.87e
T_7	61.43d	61.77d	0.56c	0.56c	12.55d	12.51d
T_8	72.79b	73.06b	0.68b	0.67b	14.36b	14.42b
T_9	65.76c	65.59c	0.53c	0.54c	13.53c	13.51c
T_{10}	82.48a	82.29a	0.72a	0.75a	14.64b	14.58b
T_{11}	73.45b	73.72b	0.65b	0.67b	15.47a	15.63a
T_{12}	67.04c	67.27c	0.55c	0.53c	14.24b	14.34b
T_{13}	83.50a	83.40a	0.75a	0.76a	15.70a	15.82a

Means not sharing the same letter(s) with each column is significantly different at a 0.05 level of probability.

2. Yield Components:

2. 1 Number of Fruits Per Tree:

The results representing the effect of the abovementioned treatments on the number of fruits per tree of "African Rose" plums in both seasons are shown in Table (3). In general, the obtained results indicated that all foliar applications increased the number of fruits per tree as compared with the control during both seasons. Foliar application with 30 ppm TDZ + 1 ppm Br +1%KNO_3 treatment provided the highest increment in the number of fruits, followed by 20 ppm TDZ + 0.5 ppm Br +0.5% KNO_3 application treatment and 30 ppm TDZ + 1% KNO_3 treatment or 30 ppm TDZ + 1 ppm Br as compared with the control in both seasons.

A gradual increase in number of fruits per tree was observed with trees treated with 30 ppm TDZ + 1 ppm Br +1%KNO_3 treatment (321.00 and 325.00, each in turn) and 20 ppm TDZ + 0.5 ppm Br + 0.5% KNO_3 application treatment (316.00 and 310.00, serially) as compared with the control (255.00 and 245.00, each in turn) in the two seasons, followed by 30 ppm TDZ + 1% KNO_3 application treatment (307.66) and 30 ppm TDZ + 1 ppm Br (302.33) in the first season, followed by 30 ppm TDZ + 1 ppm Br (304.33) application treatment and 30 ppm TDZ + 1% KNO_3 (298.66) in the second season.

2. 2 Fruit Weight (g):

As for the effects of thidiazuron, brassinosteroids and K- nitrate treatments on the fruit weight of "African Rose" plums in both, results of Table (3) showed that all treatments, significantly ($P \leq 0.05$) increased fruit weight as compared with the control treatment during both seasons. 30 ppm TDZ + 1 ppm Br +1% KNO_3 application treatment or 30 ppm TDZ + 1% KNO_3 treatment gave the highest fruit weight (78.00 and 78.75 g), (76.66 and 77.03 g), respectively followed by 20 ppm TDZ + 0.5 ppm Br +0.5% KNO_3 treatment or 20 ppm TDZ + 0.5% KNO_3 application treatment (75.80 and 76.13 g), (75.50 and 76.01 g), each in turn, as compared with check plot treatment (51.66 and 50.25 g) in both seasons.

2.3 Yield (kg/tree):

The results concerning the effect of thidiazuron, brassinosteroids and potassium nitrate treatments on the yield (kg/tree) of "African Rose" plum trees in both seasons are listed in Table (3). The average values indicated that all treatments, significantly ($P \leq 0.05$) increased yield (kg/tree) as compared with the control. It was evident that the application of 30 ppm TDZ + 1 ppm Br +1% KNO_3 treatment or 20 ppm TDZ + 0.5 ppm Br +0.5% KNO_3 application treatment caused a higher significant increase in yield (25.03 and 25.59 kg/tree), (23.95 and 23.60 kg/tree), each in turn, as compared with the control (13.17 and 12.31 kg/tree). Also, both 30 ppm TDZ + 1% KNO_3 treatment (23.58 and 23.20 kg/tree) and 20 ppm TDZ + 0.5% KNO_3 application treatment (21.64 and 21.87 kg/tree) significantly ($P \leq 0.05$) increased yield (kg/tree) as compared with the control in both seasons.

2.4 Total Yield (ton/feddan):

Pertaining to the results of total yield (ton/feddan) of "African Rose" Plum trees as affected by thidiazuron, brassinosteroids and potassium nitrate in both seasons, the results of Table (3) revealed that all treatments, significantly ($P \leq 0.05$) increased yield (ton/feddan) as compared with the control. It was evident that the application of 30 ppm TDZ + 1 ppm Br +1% KNO_3 treatment or 20 ppm TDZ + 0.5 ppm Br +0.5% KNO_3 application treatment caused a higher significant increase in yield (17.52 and 17.91 ton/feddan), (16.76 and 16.52 ton/feddan), each in turn, as compared with the control (9.21 and 8.61 ton/feddan). Also, both 30 ppm TDZ + 1% KNO_3 treatment (16.50 and 16.24 ton/feddan) and 20 ppm TDZ + 0.5% KNO_3 application treatment (15.14 and 15.30 ton/feddan) significantly ($P \leq 0.05$) increased yield (ton/feddan) as compared with the control in both seasons.

The present study showed results similar to those obtained by Mateus *et al.* (2017). In which TDZ application increased the yield. This hypothesis is based on recent findings showing that cytokinin acts to inhibit leaf senescence (Zwack and Rashotte 2013), by

altering sink-source balance. The above-mentioned results of BRs are in line with those obtained by Marzouk and Kassem (2011) and Ahmed *et al.* (2015). who cleared that BRs have a specific effect on differentiation; Mussig (2005) who reported that physiological pathways of BRs include effects on carbohydrate assimilation and allocation. Additionally, Montoya *et al*. (2005) showed that BRs are essential for many physiological functions in plants. Preharvest addition of K nitrate positively enhanced fruit weight according to Jawandha *et al*. (2017). Also, Al-Bamarny *et al*. (2010b) reported that Potassium activates several enzymes, including those involved in the synthesis of carbohydrates, and is also involved in the neutralization of organic acids and the promotion of normal cell division and growth.

Table 3. Reproductive growth parameters of "African Rose" Plums as affected by thidiazuron, brassinosteroids and potassium nitrate during both the 2020 and 2021 seasons**.**

Treatments	Number of fruits / tree		Fruit weight (g)		Yield (kg/tree)		Yield (ton/feddan)	
	2020	2021	2020	2021	2020	2021	2020	2021
T_1	255.00f	245.00g	51.66f	50.25f	13.17h	12.31g	9.21h	8.61g
T_2	282.0[d]	284e	71.93c	72.26c	20.28e	20.52d	14.19e	14.36d
T_3	294.66c	286.00e	72.20bc	73.13bc	21.27cd	20.91cd	14.89cd	14.63cd
T_4	273.00e	266.33f	57.00e	56.56e	15.56g	15.06f	10.89g	10.54f
T_5	274.33e	268.66f	59.00e	58.06e	16.18g	15.59f	11.32g	10.91f
T_6	270.00e	263.33f	64.66d	66.08d	17.45f	17.40e	12.21f	12.18e
T_7	270.33e	262.00f	63.00d	64.25d	17.03f	16.83e	11.92f	11.78e
T_8	296.00c	289.00e	70.30c	70.00c	20.80de	20.23d	14.56de	14.16d
T_9	286.66d	295.66d	75.50ab	76.01ab	21.64c	21.87c	15.14c	15.30c
T_{10}	316.00a	310.00b	75.80a	76.13ab	23.95b	23.60b	16.76b	16.52b
T_{11}	302.33b	304.33c	70.80c	71.10c	21.40cd	21.63c	14.98cd	15.14c
T_{12}	307.66b	298.66d	76.66a	77.03a	23.58b	23.20b	16.50b	16.24b
T_{13}	321.00a	325.00a	78.00a	78.75a	25.03a	25.59a	17.52a	17.91a

Means not sharing the same letter(s) with each column are significantly different at 0.05 level of probability.

3. Fruit Physical Parameters:

3.1 Fruit size (cm^3):

The effect of various applied treatments on the fruit size of "African Rose" plum trees was calculated and tabulated in Table (4). The results showed that 30 ppm TDZ + 1 ppm Br +1%KNO_3 treatment, 30 ppm TDZ + 1 ppm Br and 30 ppm TDZ application treatment, significantly ($P \leq 0.05$) increased fruit size as compared with the control. 30 ppm TDZ + 1 ppm Br +1% KNO_3 treatments and 30 ppm TDZ + 1 ppm Br treatments; gave the highest fruit size (98.40 and 99.03 cm^3), (95.66 and 96.22 cm^3), respectively followed by 30 ppm TDZ and 20 ppm TDZ + 0.5 ppm Br +0.5% KNO_3 treatments (85.21 and 84.81 cm^3), (84.07 and 84.62 cm^3), each in turn, as compared with check plot treatment (62.78 and 64.08 cm^3) in both seasons. Generally, 30 ppm TDZ + 1 ppm Br +1%KNO_3 treatments and 30 ppm TDZ + 1 ppm Br treatments caused higher fruit size by 98.40 and 95.66 cm^3 during the first season and by 99.03 and 96.22 cm^3 in the second season respectively, as compared with the control.

3.2 Fruit Length (cm):

Results express the effect of experimental treatments on the fruit length of "African Rose" plum trees in both seasons are shown in Table (4) the obtained results indicated that all application treatments, significantly ($P \leq 0.05$) increased fruit length as compared with the control. 30 ppm TDZ + 1 ppm Br +1% KNO_3 and 30 ppm TDZ + 1% KNO_3 treatments gave the highest fruit length (5.43 and 5.47 cm), (5.36 and 5.47 cm), respectively followed by 30

ppm TDZ and 20 ppm TDZ + 0.5 ppm Br +0.5% KNO_3 treatments (5.38 and 5.43 cm), (5.34 and 5.41 cm), each in turn, as compared with the control treatment (4.80 and 4.61 cm) in both seasons.

3.3 Fruit Diameter (cm):

The results representing the effect of the abovementioned treatments on fruit diameter are shown in Table (4) the obtained results indicated that all treatments, significantly ($P \leq 0.05$) increased fruit diameter as compared with the control in both seasons. A gradual increase in fruit diameter was observed with trees treated with 30 ppm TDZ + 1 ppm Br +1% KNO_3 treatment (5.53 and 5.58 cm, each in turn) and 30 ppm TDZ + 1 ppm Br application treatment (5.43 and 5.49 cm, serially), followed by 30 ppm TDZ treatment (5.41 and 5.41 cm, each in turn) and 20 ppm TDZ + 0.5 ppm Br (5.23 and 5.39 cm, serially) as compared with the control (4.51 and 4.58 cm, each in turn) in the two seasons, respectively.

3.4 Fruit Firmness (lb/Inch^2):

The analysis results of the effects of TDZ, BRs and KNO_3 applications treatments on fruit firmness (lb/inch^2) are presented in Table (4). (30 ppm TDZ + 1 ppm Br +1% KNO_3) and (30 ppm TDZ + 1 ppm Br) treatments, significantly ($P \leq 0.05$) increased fruit firmness as compared with the control, while no significant differences were recorded between 0.5% KNO_3, 1% KNO_3 treatments compared to control treatment in both seasons. A gradual increase in fruit firmness was observed with trees treated with 30 ppm TDZ + 1 ppm Br +1% KNO_3 treatment (15.03 and 15.13 lb/inch^2, each in turn) and 30 ppm TDZ + 1 ppm Br application treatment (14.86 and 14.99 lb/inch^2, serially), followed by 30 ppm TDZ + 1% KNO_3 application treatment (13.85 and 13.96 lb/inch^2, respectively) and 20 ppm TDZ + 0.5 ppm Br (13.76 and 13.87 lb/inch^2, consecutively) as compared with the control (11.66 and 11.74 lb/inch^2, each in turn) in the two seasons, respectively.

These findings of thidiazuron treatments agreed with those obtained by Famiani *et al.* (2007) who cleared that TDZ treatment, increased fruit length, fruit diameter and fruit size, it has also been reported for kiwifruit (Famiani *et al.*, 2002); (Al-Jumaily and Al-Esawi, 2016) on apple trees and Stern *et al.* (2003). Mateus *et al.* (2017) confirmed that spraying with TDZ treatments increased flesh firmness. TDZ effect was achieved through a direct enhancement of fruit cell division. TDZ increased fruit size without affecting fruit shape or return yield in the year following application (Stern *et al.*,2003; Fagundes *et al.*, 2016). The effectiveness of this substance lies in its ability to stimulate cell growth and division, activate nutrient absorption and metabolism, delay the aging of plant tissue, boost photosynthesis, regulate plant hormones and have other effects as noted by Guo *et al.* (2011) and Nisler (2018). The above results of brassinolide treatments were supported by the findings of Wang *et al.* (2019) on Citrus grandis cv. 'Huangjinmiyou' and 'Hongroumiyou'.; Thapliyal *et al.* (2016); Aly *et al.* (2021), noticed that the foliar application treatments of brassinolide at 1.5mg/L and 2mg/L treatments significantly increased fruit length, fruit diameter and fruit size. Roghabadi and Pakkish (2014) and EL-Boray *et al.* (2015) found that foliar applications of brassinolide increased fruit firmness at harvest. These results may be described by the positive action of brassinolide may enhance both cell division and cell enlargement and has a great role in activating the biosynthesis of proteins, RNA and DNA as well as reducing pre-harvest fruit drop (Fathi *et al.*, 2013). K- nitrate activates many enzymes, including those involved in the synthesis of carbohydrates, and is also involved in the neutralization of organic acids and the promotion of cell division and growth (Al-Bamarny *et al.*, 2010b). Preharvest application of potassium nitrate at 1% positively enhanced plums' fruit length, diameter and firmness, especially fruit size Jawandha *et al.* (2017). Foliar application of potassium nitrate leads to improved fruit quality in mango fruits (Lokesh *et al.* 2020).

Table 4: Fruit physical parameters of "African Rose" Plums as affected by thidiazuron, brassinosteroids and potassium nitrate in both seasons.

Treatments	Fruit size (cm^3)		Fruit length (cm)		Fruit diameter (cm)		Fruit firmness ($Ib/inch^2$)	
	2020	2021	2020	2021	2020	2021	2020	2021
T_1	62.78e	64.08e	4.80cd	4.61d	4.51f	4.58e	11.66d	11.74d
T_2	74.27d	75.47d	5.00bc	4.84cd	5.00cde	4.88de	13.21c	13.18c
T_3	85.21b	84.81b	5.38a	5.43a	5.41ab	5.41ab	13.80b	13.94b
T_4	73.59d	74.41d	4.51d	4.85cd	4.88de	4.90de	13.13c	13.12c
T_5	75.24d	75.74d	4.81cd	5.08bc	4.82ef	5.08bcd	13.20c	13.17c
T_6	72.39d	74.09d	4.74cd	4.88cd	4.85de	4.92de	11.95d	11.89d
T_7	71.77d	72.38d	4.77cd	4.82cd	4.78ef	4.87de	11.78d	11.81d
T_8	82.80bc	83.89bc	4.92c	4.98c	5.23abc	5.39ab	13.76b	13.87b
T_9	80.66c	81.00c	4.94c	5.03bc	4.99cde	5.03cd	13.23c	13.20c
T_{10}	84.07bc	84.62b	5.34a	5.41a	5.17bcd	5.11bcd	13.69b	13.72bc
T_{11}	95.66a	96.22a	5.29ab	5.33ab	5.43ab	5.49a	14.86a	14.99a
T_{12}	83.75bc	84.88b	5.43a	5.47a	5.16bcd	5.36abc	13.85b	13.96b
T_{13}	98.40a	99.03a	5.36a	5.47a	5.53a	5.58a	15.03a	15.13a

Means not sharing the same letter(s) with each column is significantly different at a 0.05 level of probability.

4. Fruit Chemical Parameters:

4.1 Total Soluble Solids (%):

Concerning with influence of thidiazuron, brassinosteroids and potassium nitrate applications treatments on total soluble solids "African Rose" fruits in both seasons, data in table (5) cleared that all treatments, significantly increased total soluble solids as compared with the control, except 20 ppm TDZ and 30 ppm TDZ treatment during both seasons. A gradual increase in total soluble solids was observed with trees treated with 0.5% KNO_3 application treatment (15.48%) and 1% KNO_3 (15.45 %), followed by 30 ppm TDZ + 1 ppm Br +1% KNO_3 treatment (14.72 %) and 20 ppm TDZ + 0.5 ppm Br +0.5% KNO_3 treatment (14.64 %) as compared with the control (11.45%) during the first season, while in the second season, a significant rise was observed with trees treated with 1% KNO_3 application treatment (15.52 %) and 0.5% KNO_3 treatment (15.50 %), followed by 30 ppm TDZ + 1 ppm Br +1% KNO_3 treatment (14.70 %) and 20 ppm TDZ + 0.5 ppm Br + 0.5% KNO_3 treatment (14.60 %) as compared with the control (11.40%).

4.2 Acidity (%):

In regard to the results of fruit juice acidity (%) in response to TDZ, BRs and KNO_3 treatments, the results in Table (5) revealed that, all treatments, significantly ($P \leq 0.05$) decreased fruit juice acidity (%) as compared with the control in both seasons. A gradual decrease in fruit juice acidity was observed with trees treated with 30 ppm TDZ + 1 ppm Br +1% KNO_3 treatment (0.91 and 0.92 %, each in turn) and 30 ppm TDZ + 1% KNO_3 application treatment (0.92and 0.92 %, serially), followed by 30 ppm TDZ + 1 ppm Br application treatment (0.92 and 0.94 %, respectively) and 20 ppm TDZ + 0.5 ppm Br +0.5% KNO_3 (0.93 and 0.95 %, consecutively) as compared with the control (1.42 and 1.40 %, each in turn) in the two seasons, respectively.

4.3 Total Sugars (%):

The results given in Table (5) represent the effect of used treatments on total sugars (%) of "African Rose" fruits during both studied seasons. The results indicated that all treatments, significantly ($P \leq 0.05$) increased total sugars as compared with the control in both

seasons. A gradual boost in fruit total sugars was observed with trees treated with 1% KNO_3 (9.96 and 9.95 %, each in turn) and 0.5% KNO_3 application treatment (9.94 and 9.90 %, serially), followed by 30 ppm TDZ + 1 ppm Br +1% KNO_3 (9.88 and 9.90 %, respectively) and 30 ppm TDZ + 1% KNO_3 (9.84and 9.83 %, consecutively) as compared with the control (7.69 and 7.81 %, each in turn) in the two seasons, respectively.

4.4 Anthocyanin (mg/100g F.W.):

The results concerning the effect of TDZ, BRs and KNO_3 during treatments on anthocyanin of "African Rose" fruits, in both seasons, are listed in Table (5). The results of both experimental seasons indicated that, that all treatments, significantly ($P \leq 0.05$) increased anthocyanin as compared with control treatment in both seasons. A gradual increase in anthocyanin was observed with trees treated with 30 ppm TDZ + 1 ppm Br +1% KNO_3 treatment (13.20 and 13.34 mg/100g F.W., each in turn) and 20 ppm TDZ + 0.5 ppm Br +0.5% KNO_3 (12.85 and 12.91 mg/100g F.W., serially), followed by 1 ppm Br (12.55 and 12.82 mg/100g F.W., respectively), followed by 0.5 ppm Br (12.25 mg/100g F.W.) and 1% KNO_3 treatment (12.07 mg/100g F.W.) during the first season (2020), followed by 1% KNO_3 (12.24 mg/100g F.W.) and 0.5 ppm Br treatment (12.09 mg/100g F.W.) during the second season (2021) as compared with the control (6.65 and 6.50 mg/100g F.W., each in turn) in the two seasons, respectively.

4.5 Vitamin C (mg/100 ml juice):

In concerning with influence of TDZ, BRs and KNO_3 applications treatments on vitamin C of "African Rose" fruits in both seasons, results in Table (5) cleared that all treatments, significantly increased vitamin C as compared with the control in the two seasons. A gradual increase was observed with trees treated with 30 ppm TDZ + 1 ppm Br +1% KNO_3 application treatment (7.50 and 7.51 mg/100 ml juice, each in turn) and 20 ppm TDZ + 0.5 ppm Br +0.5% KNO_3 (7.48 and 7.47 mg/100 ml juice, serially), followed by 30 ppm TDZ + 1 ppm Br treatment (7.46 and 7.46 mg/100 ml juice, each in turn) and 20 ppm TDZ + 0.5 ppm Br (7.44 and 7.45 mg/100 ml juice, serially) as compared with the control (4.31 and 4.44 mg/100 ml juice, each in turn) in both seasons.

The above-mentioned results of thidiazuron are in line with those obtained by Mateus *et al.* (2017) on pear trees they cleared that spraying thidiazuron increased total soluble solids, total sugars, anthocyanin and vitamin C but decreased acidity. Its physiological efficacy is activating the translocation and assimilation of metabolic materials, enhancing photosynthesis activity, and hormonal regulation of plant morphogenesis according to Guo *et al.* (2011) and Nisler (2018). These findings of brassinolide treatments agreed with those obtained by (Tadaion *et al.*, 2014) on 'Khalili' grapevine; Roghabadi and Pakkish (2014) on 'Tak Danehe Mashhad' sweet cherry, they all found that brassinolide treatments significantly increased total soluble solids, total sugars, anthocyanin and vitamin C. Thapliyal *et al.* (2016) on pear and Ghosh *et al*. (2022). The application of BR can lead to an increase in sugars in fruits, as BR indirectly increases the content of abscisic acid (ABA), which in turn induces the sugar metabolic pathway. A foliar spray of BR can be helpful in increasing the sugar levels due to the better assimilating power of leaves over a longer period. The synergistic activity of BR can also increase the metabolic activities in various crops, which can lead to an increase in the rate of photosynthesis and chlorophyll content, ultimately affecting the overall quality of the fruits, BR can have a positive impact on the overall quality of fruits (Thapliyal *et al.*, 2016). Abd El-Baree *et al.* (2013), worked on 'Costata' persimmon trees; Aly *et al*. (2018) worked on 'Anna' apple trees. and (Mohamed and Sherif, 2015) on 'Florida Prince' peach trees they all found that brassinolide treatments significantly decreased the percentage titratable acidity. The reason for the decrease in fruit titratable acidity may be due to the metabolic changes with the fast conversion of organic acids into sugars and their derivatives by reactions involving the reversal of the glycolytic pathway or being used in respiration (Mostafa and Kotb, 2018). The above-mentioned results of potassium nitrate are

in line with those obtained by Hashem *et al*. (2020); Gill *et al*. (2012) on 'Patharnakh' pear; Prasad *et al*. (2015) on pear trees 'Pathernakh.' On the other hand, the same trends of these results of potassium nitrate treatments were found by Shanmugasundaram and Balakrishnamurthy (2017), who found spraying potassium nitrate increased total soluble solids, total sugars, anthocyanin and vitamin C, also, Jawandha *et al*. (2017) reported that spray of potassium nitrate decreased titratable acidity on plum ' Satluj purple. Al-Bamarny *et al.* (2010b) found that the foliar application of K activates several enzymes, such as those involved in the synthesis of carbohydrates. Additionally, it plays a crucial role in neutralizing organic acids and promoting normal cell division and growth. Foliar spray of K- nitrate could be a possible improvement in the translocation of assimilates into the fruits and plays an important role in the interplay of metabolic events involved in fruit ripening and senescence (Vikramjeet and Kaur, 2018). It is crucial for many biochemical reactions that are essential for enzyme activation and physiological processes in cells (Anees *et al.,* 2016).

Table 5: Fruit chemical parameters of "African Rose" fruits as affected by thidiazuron, brassinosteroids and potassium nitrate in both seasons.

Treatments	Total sugars (%)		T.S.S (%)		Acidity (%)		Anthocyanin (mg/100g)		Vitamin C (mg/100ml juice)	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
T_1	7.69e	7.81e	11.45e	11.40e	1.42a	1.40a	6.65e	6.50e	4.31d	4.44d
T_2	8.22d	8.33cd	11.52e	11.56e	1.22b	1.21b	6.52e	6.69e	6.57b	6.54b
T_3	8.26d	8.31d	11.38e	11.41e	1.24b	1.23b	6.71e	6.78e	6.55b	6.55b
T_4	8.30cd	8.35cd	12.82d	12.74d	1.19c	1.21b	12.25b	12.09c	5.77c	5.80c
T_5	8.32cd	8.40cd	12.78d	12.81d	1.18c	1.19c	12.55ab	12.82ab	5.86c	5.85c
T_6	9.94a	9.90ab	15.48a	15.50a	1.14d	1.16d	10.94c	11.84c	5.74c	5.76c
T_7	9.96a	9.95a	15.45a	15.52a	1.12e	1.14d	12.07b	12.24bc	5.79c	5.78c
T_8	8.37cd	8.43cd	12.60d	12.63d	1.06f	1.07e	7.87d	7.77d	7.44a	7.45a
T_9	9.72b	9.76b	13.68c	13.70c	0.99g	0.98f	7.63d	7.70d	6.54b	6.58b
T_{10}	9.81ab	9.81ab	14.64b	14.60b	0.93h	0.95g	12.85ab	12.91a	7.48a	7.47a
T_{11}	8.47c	8.50c	12.64d	12.65d	0.92h	0.94g	8.10d	8.17d	7.46a	7.46a
T_{12}	9.84ab	9.83ab	13.66c	13.72c	0.92h	0.92h	8.03d	8.14d	6.58b	6.60b
T_{13}	9.88ab	9.90a	14.72b	14.70b	0.91h	0.92h	13.20a	13.34a	7.5a	7.51a

Means not sharing the same letter(s) with each column is significantly different at a 0.05 level of probability.

Conclusion:

This study led to the conclusion that thidiazuron, brassinosteroids and K- nitrate foliar application, significantly ($P \leq 0.05$) increased growth characters, number of fruits per tree, fruit weight, yield (kg/tree), total yield (ton/feddan), anthocyanin and vitamin C, moreover, TDZ at 30 ppm+ Br at 1 ppm +KNO_3 at 1% and TDZ at 30 ppm+ Br at 1 ppm application treatments, significantly ($P \leq 0.05$) increased fruit size, length, diameter and firmness as compared with the control during both seasons. On the other hand, all K- nitrate and TDZ at 30 ppm+ Br at 1 ppm +KNO_3 at 1% application, significantly ($P \leq 0.05$) increased total soluble solids (%), and total sugars but decreased fruit juice acidity (%) as compared with the control. It was evident that the application of TDZ at 30 ppm+ Br at 1 ppm +KNO_3 at 1% treatments followed by TDZ at 20 ppm+ Br at 0.5 ppm +KNO_3 at 0.5% treatments and TDZ at 30 ppm+ KNO_3 at 1% treatments application treatment caused a higher significant increase in yield (17.52 and 17.91 ton/feddan), (16.76 and 16.52 ton/feddan) and (16.50 and 16.24 ton/feddan) each in turn, as compared with the control (9.21 and 8.61 ton/feddan) in the two seasons, respectively.

Declarations:

Ethical Approval:Ethical Approval is not applicable.

Competing interests: The authors declare no conflict of interest.

Authors Contributions:I hereby verify that all authors mentioned on the title page have

made substantial contributions to the conception and design of the study, have thoroughly reviewed the manuscript, confirm the accuracy and authenticity of the data and its interpretation, and consent to its submission.

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ARABIC SUMMARY

تأثير بعض معاملات ما قبل الحصاد علي حجم وجودة ثمار البرقوق صنف "افريكان روز"

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أجريت هذه الدراسة خلال موسمى 2020 و 2021 على أشجار البرقوق صنف ' افريكان روز' مطعومة على أصل النيماجارد عمرها خمس سنوات منزرعة فى تربة رملية تروى بنظام الرى بالتنقيط بمزرعة خاصة فى منطقة النوبارية بمحافظة البحيرة بهدف دراسة تحسين حجم وجودة ثمار البرقوق صنف افريكان روز قبل الحصاد من خلال بعض منظمات النمو الجديدة مثل ثايديزيرون والبراسينوستيرويد بالإضافة إلى نترات البوتاسيوم. وكانت المعاملات: 1- كنترول، 2-ثايديزيرون 20 جزء في المليون، 3- ثايديزيرون 30 جزء في المليون، 4- براسينوستيرويد 0.5 جزء في المليون، 5-براسينوستيرويد 1جزء في المليون، 6- نترات بوتاسيوم 0.5%، 7- نترات بوتاسيوم 1%، 8- ثايديزيرون 20 جزء في المليون , براسينوستيرويد 0.5 جزء في المليون، 9- ثايديزيرون 20 جزء في المليون ونترات بوتاسيوم 0.5%، 10- ثايديزيرون 20 جزء في المليون , براسينوستيرويد 0.5 جزء في المليون و نترات بوتاسيوم 0.5%، 11- ثايديزيرون 30 جزء في المليون وبراسينوستيرويد 1 جزء في المليون، 12-ثايديزيرون 30 جزء في المليون و نترات البوتاسيوم 1%، 13- ثايديزيرون 30 جزء في المليون ,البراسينوستيرويد 1جزء في المليون ونترات البوتاسيوم 1%. وكان التصميم الإحصائي المستخدم هو القطاعات العشوائية الكاملة بخمس مكررات وقد أظهرت النتائج أن جميع المعاملات أدت الى زيادة معنوية فى النمو الخضري وعدد الثمار لكل شجرة مقارنة بمعاملة الكنترول خلال موسمي الدراسة. وقد أدت جميع المعاملات إلى زيادة معنوية في وزن الثمرة ومحصول الشجرة والمحصول الكلى للفدان و صبغة الانثوسيانين وكذلك فيتامين ج مقارنة بمعاملة الكنترول. علاوة علي ذلك، أدي استخدام المعاملة (ثايديزيرون 30 جزء في المليون + براسينوستيرويد 1جزء في المليون + نترات بوتاسيوم 1%) والمعاملة (ثايديزيرون 30 جزء في المليون + براسينوستيرويد 1جزء في المليون) الي زيادة معنوية فى حجم وطول وعرض وصلابة الثمرة مقارنة بمعاملة الكنترول وباقي المعاملات خلال موسمي الدراسة. علاوة على ذلك أدت معاملات الرش بنترات البوتاسيوم بتركيز(0.5%، 1%) و(ثايديزيرون 30 جزء في المليون + براسينوستيرويد 1جزء في المليون + نترات بوتاسيوم 1%) الى زيادة معنوية في نسبة المواد الصلبة الذائبة ونسبة السكريات الكلية وأدت الى انخفاض معنوي فى نسبة حموضة العصير مقارنة بمعاملة الكنترول وباقي المعاملات خلال موسمي الدراسة.