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IMPACT OF GIBBERELLIC ACID AND BORON TRIOXIDE NANOPARTICLES FOLIAR SPRAYING ON GROWTH, YIELD AND FRUIT QUALITY OF "ZAGHINIA" APRICOT TREES

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Abstract

To determine the extent of growth response and yield of apricot trees cv. Zaghinia to foliar spraying with gibberellic acid at 0, 25, 50, and 75 mg L^{-1} and boron trioxide nanoparticles at 0, 10, and 20 mg L^{-1}. A field trial was executed in a private orchard, in the governorate of Anbar, Iraq, during the growing season of 2023, in which trees were sprayed a week after full bloom, followed by two sprays at a three-week interval. A factorial experiment (4 x 3) on 36 trees, 7 years old was performed using a Randomized Complete Block Design (RCBD). With three replications and one tree for the experimental unit. Among all the treatments applied, (GA_3 at 75 mg L^{-1} + Nano-boron at 20 mg L^{-1}) treatment performed the highest annual shoot length (46.51 cm), chlorophyll content (41.04 mg 100 g^{-1} fresh weight), fruit set (53.86%), fruit retention (41.69%), fruit yield (14.43 kg $tree^{-1}$), fruit weight (25.59 g), fruit volume (32.84 cm^3), total soluble solids (15.12%) and carotene content (0.270 mg 100 g^{-1}). While the treatment (GA_3 at 25 mg L^{-1} + Nano-boron at 20 mg L^{-1}) gave the highest shoot diameter (5.06 mm), and lowest acidity (0.81%). On the other hand, the control treatment recorded the lowest values, amounting to (26.61 cm, 4.91 mm, 34.11 mg 100 g^{-1} fresh weight, 39.27%, 30.19%, 8.56 kg $tree^{-1}$, 17.92 g, 25.81 cm^3, 13.53%, and 0.106 mg 100 g^{-1}) for the traits length and diameter of annual shoots, chlorophyll content, fruit set and retention, total yield, fruit weight and volume, TSS, and carotene content respectively.

Keywords: Apricot, Foliar application, Gibberellic acid, Nano-boron, Fruit yield.

تأثير الرش الورقي بحامض الجبرليك وثلاثي اوكسيد البورون النانوي في نمو وحاصل اشجار المشمش صنف زاغينيا

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الخلاصة

لبيان مدى استجابة نمو وحاصل اشجار المشمش صنف زاغينيا للرش الورقي بحامض الجبرليك (0، 25، 50 و75 ملغم لتر$^{-1}$) وثلاثي اوكسيد البورون النانوي (0، 10 و20 ملغم لتر$^{-1}$) نفذت تجربة حقلية في أحد بساتين الفاكهة الخاصة التابعة لمحافظة الانبار، العراق خلال موسم النمو 2023، حيث تم رش الاشجار بعد اسبوع من الازهار الكامل تبعها رشتان بفاصل زمني ثلاثة اسابيع. نفذت تجربة عاملية (4 x 3) على 36 شجرة بعمر سبعة سنوات بتصميم القطاعات الكاملة المعشاة Randomized Complete Block Design (RCBD) وبثلاثة مكررات وتمثلت الوحدة التجريبية بشجرة واحدة. بينت نتائج الدراسة ان معاملة التداخل (75 ملغم لتر$^{-1}$ حامض الجبرليك + 20 ملغم لتر$^{-1}$ بورون نانوي) قد تفوقت معنويا من خلال تحقيقها اعلى معدل لطول الافرع الحديثة (46.51 سم)، محتوى الكلوروفيل (41.04 ملغم 100 غم$^{-1}$ وزن طري)، نسبة عقد الثمار (53.86%)، نسبة بقاء الثمار (41.69%)، حاصل الثمار (14.43 كغم شجرة$^{-1}$)، وزن الثمرة (25.59 غم)، حجم الثمرة (32.84 سم^{3})، نسبة المواد الصلبة الذائبة الكلية (15.12%) ومحتوى الكاروتين (0.270 ملغم 100 غم$^{-1}$). بينما حققت المعاملة (25 ملغم لتر$^{-1}$ حامض الجبرليك + 20 ملغم لتر$^{-1}$ بورون نانوي) اعلى معدل لقطر الافرع (5.06 ملم)، وادنى نسبة حموضة (0.81%). من جانب اخر سجلت معاملة المقارنة اقل القيم التي بلغت (26.61 سم، 4.91 ملم، 34.11 ملغم 100 غم$^{-1}$ وزن طري، 39.27%، 30.19%، 8.65 كغم شجرة$^{-1}$، 17.92 غم، 25.81 سم^{3}، 13.53% و0.106 ملغم 100 غم$^{-1}$) لصفة طول وقطر الافرع الحديثة، محتوى الكلوروفيل الكلي، نسبة عقد وبقاء الثمار، حاصل الشجرة، وزن وحجم الثمرة، نسبة المواد الصلبة الذائبة ومحتوى الكاروتين بالتتابع.

كلمات مفتاحية: المشمش، الرش الورقي، حامض الجبرليك، البورون النانوي، حاصل الثمار.

Introduction

Apricot, belonging to Rosaceae family, is considered one of the economically significant stone fruit types in the world. Scientifically known as *Prunus armeniaca* L., it was also formerly referred to as *Prunus vulgaris* L. It was previously believed to have originated in Armenia, hence the Romans called it the "Armenian apples" (34). However, studies have proven that its original habitat is in northeastern China, where it was found in its wild form in natural forests, particularly in the Himalayas, southern Manchuria, and Mongolia, which apricot have been known in China for more than 5000 years (14 and 27).

The "Zaghinia" apricot cultivar is regarded as one of the most commercial varieties in Iraq due to its low to moderate chilling requirements, along with outstanding quality and flavour. Fruits are elliptic in shape, medium-sized, sweet, and juicy of reddish-orange. This cultivar bears abundant and regular crop and ripens in the third week of May when there aren't other fruits available in the markets (7).

Despite the favorable environmental conditions for growing apricots in Iraq, it is still lagging behind for several reasons, including the limited cultivated areas and the low tree productivity compared to global production. Apricot cultivars rarely suffer from alternate bearing phenomenon as they bloom annually and bear relatively large quantities of flowers and fruits, leading to a large amount dropping of them after pollination and before harvest, in addition to the decrease in quality traits and small size in many cases (4). All of these represent problems for farmers, producers, and consumers. Therefore, studies continue to find solutions to these problems or at least some of them, such as the application of some growth regulators that are widely used in the production of stone fruit for their role in increasing fruit set and reducing dropping, as well as enhancing volume and quality (32).

Gibberellic acid (GA_3) is one of the most biologically active gibberellins and is commercially used in fruit orchards for its effective role in improving both vegetative and fruit growth, as well as enhancing the quality of horticultural crops through various biological effects via cell elongation and expansion, increasing photosynthetic efficiency, chlorophyll and carotenoids biosynthesis, stimulate flowering, fruit set, regulate cellular membranes permeability, control enzymatic activity and metabolic processes, and promoting the synthesis and production of nucleic acids and proteins (15, 17 and 29). The findings of numerous studies have indicated the significance of gibberellic acid foliar applied in boosting growth characteristics and yields of apricot trees, including (1, 3, 18, 21 and 28).

One of the key technologies in the twenty-first century that contributes to enhancing agricultural practices and sustainable development is nanotechnology (19 and 20). Nanofertilizers can be a suitable alternative to chemical fertilizers due to their high surface area-to-volume ratio and high penetration ability. Moreover, they play a role in boosting nutrient use efficiency by enabling a slow constant release of nutrients thus assisting nutrient plant uptake for the longest possible duration this reflects positively on reducing fertilization input and reducing environmental hazards to a large extent (37, 38 and 40).

Boron is an essential micronutrient for the physiological functioning of plants. It has an important role in the maintenance of cell wall structure and integrity, enzymatic activity associated with plasmalemma, potassium transportation into guard cells thus regulation of the movement of stomata, boosting chlorophyll content, ion flux across the membranes, cells division and elongation, meristematic tissues activity, carbohydrate and nitrogen metabolism, sugar transport, nucleic acids, indole-3-acetic acid, and phenol metabolism and transport, flower development, pollen germination along with pollen tube growth (5, 33, 39 and 41). Many studies have confirmed the significance of boron spraying for its important role in enhancing vegetative growth, pollination, fruit set and fruit retention percentage, along with improving fruit yield and their physicochemical traits, including pomegranate by (16 and 22), olive by (23 and 25), mango by (2), and sweet orange by (26).

The present study aims to enhance growth, yield, and quantitative and qualitative traits of apricot cv. "Zaghinia" by foliar application of gibberellic acid and nano boron trioxide, along with determining the most efficient treatment to address the mentioned issues independently or collectively.

Materials and Methods

The present investigation was executed in a private orchard in Zoigher village, situated 18 kilometers northwest of Ramadi city, Anbar governorate, Iraq, through the growing season of 2023, on Zaghinia apricot, aged 7 years, planted in a 4 x 4-meter spacing, irrigated by a surface irrigation system, and trained according to the modified leader system, to assess the impact of spraying with different levels of gibberellic acid, as well as nano-boron in growth, fruit yield, and its physical and chemical traits.

Service Operations: Thirty-six similar-sized and equally vigorous trees were selected as much as possible and underwent all necessary service operations, including weeding, and regular pest and disease control. Additionally, the trees were pruned at the beginning of the winter season during the rest period by removing dead and broken branches, as well as thinning out overlapping and overcrowded branches. Furthermore, a comprehensive fertilization program was implemented, incorporating the addition of organic fertilizers at 10 kg per tree during the winter season (mid-January) (10), along with a chemical fertilization program involving the addition of 100 g N per tree, 50 g P per tree, and 50 g K per tree at the beginning of March, with phosphorus and potassium fully added and two-thirds of the nitrogen added, while the remaining third was added at the beginning of April (35). Samples were taken from the orchard soil prior conducting the experiment regarding the laboratory analysis to determine their physical and chemical attributes, as detailed in Table 1.

Table 1: Physical and chemical properties of the tested soil.

Particles size distribution (%)						Available nutrients ($mg\ kg^{-1}$)			
Clay	**Sand**	**Silt**	**Texture**	**pH**	**EC (1:2.5 extract) ($ds\ m^{-1}$)**	**O.M. (%)**	**N**	**P**	**K**
28	37	35	Sand loamy	7.4	1.8	1.23	48.4	4.7	105.6

Study Factors: The experiment included two factors: Gibberellic acid foliar application (99% assay) at 0, 25, 50 and 75 mg L^{-1} and symbolised by G_0, G_{25}, G_{50}, and G_{75}, respectively. The second factor is nano boron trioxide spraying at 0, 10, and 20 mg L^{-1}, which are symbolized as B_0, B_{10}, and B_{20}, respectively. Nano-boron was prepared in the laboratories of the Ministry of Science and Technology by heating boric acid (above 300 ^{O}C), to obtain the compound boron trioxide according to the method mentioned in (30), and then convert the powder from microsized to nanosized using a ball mill for two hours according to the method of (6). The crystallite size of the nanostructure of particles after 2 h of milling the sample became approximately 20-40 nm with around shape by examining it with a transmission electronic microscopy.

Trees were sprayed with the growth regulator and nano-boron three times during the growing season. The first spraying was conducted a week after full bloom, followed by two sprayings at an interval of three weeks.

Experimental Design and Statistical Analysis: A factorial experiment (4 x 3) was conducted using a Randomized Complete Block Design (RCBD) with three replications. The experimental unit consisted of one tree (9). The findings were statistically analyzed using the program Genestat statistical analysis. Means were compared utilizing the test least significant difference (L.S.D.) at a 0.05 probability level.

Studied Traits:

Vegetative Growth: It was measured in the first week of July and included:

Length (cm) and diameter (mm) of annual shoots: Ten annual shoots were chosen randomly from the circumference of every tree, the shoots length was measured using a metric tape. The diameter was measured using an electronic caliper.

Leaf area (cm^2) and Total chlorophyll content (mg 100 g^{-1} F.W.): Twenty fully expanded leaves were collected randomly from the middle of the shoots in all directions for each experimental unit and were measured the leaf area by using a portable laser leaf area meter (model CI-203, manufactured by CID Inc., Camas, WA, USA). The content of total chlorophyll in the same leaf samples was estimated according to (12).

Fruiting:

Fruit set (%): Four fruiting arms of equal lengths were selected, distributed in all directions as much as possible. The flowers on the chosen arms were tallied at full bloom on 8th March 2023, and then, 10 days later, the fruits were tallied. The fruit set percentage was calculated according to the equation:

Fruit set % = (total number of fruit set on marked arms / total number of flower on marked arms) x 100

Fruit retention (%): The total fruits number remaining on the labelled arms at harvest was calculated, and the fruit retention percentage was determined according to the equation:

Fruit retention % = (total number of fruit retained on marked arms / total number of fruit set on marked arms) x 100

Fruit Yield (kg tree^{-1}): The fruit yield was computed per tree in the third week of May by summing the weight of harvested fruits from each tree.

Physico-chemical Traits: It was measured in the third week of May and included:

Fruit weight (g) and volume (cm^3): The average weight of fruit was determined using a sensitive electronic balance, and the average fruit volume was measured following the water-displacement method from the measuring cylinder stuffed with tap water up to a certain graduation. This was done for ten fruits from each experimental unit at maturity in the third week of May.

Fruit soluble solids content (%): TSS content was estimated using a hand refractometer according to (11).

Titratable acidity (%): The acidity percentage based on citric acid was estimated according to (36).

Carotene pigment (mg 100 g^{-1}): The carotene pigment (*B*-Carotene) was estimated in fruit peels of the soft fruits using a UV spectrophotometer based on the method described by (24).

Results and Discussion

Length and diameter of annual shoots, leaf area, chlorophyll content, fruit set and retention: The findings in Table 2 demonstrate that spraying with gibberellic acid revealed a significant effect on most vegetative traits as well as fruit set and fruit retention, especially at concentration G_{75}, which exhibited significant superiority compared to other treatments. It recorded the highest values for annual shoot length, leaf area, total chlorophyll content, per cent fruit set and fruit retention, at 44.14 cm, 19.22 cm^2, 40.30 mg 100 g^{-1} FW, 51.64%, and 39.96%, respectively. Conversely, G_0 concentration recorded lowest values, at 28.39 cm, 17.79 cm^2, 36.24 mg 100 g^{-1} FW, 41.58%, and 33.15%, respectively. Additionally, spraying with growth regulator did not reach a significant level for the trait of annual shoots diameter.

The foliar spray with nano boron trioxide had a significant influence on increasing vegetative traits, fruit set and fruit retention percentage. The B_{20} level achieved the highest values, at 39.09 cm, 5.02 mm, 18.68 cm^2, 39.32 mg 100 g^{-1} FW, 50.39%, and 39.18%, respectively. Whereas, the B_0 level recorded the lowest values, at 33.20 cm, 4.92 mm, 18.16 cm^2, 37.40 mg 100 g^{-1} FW, 44.84%, and 34.82%, respectively.

The outcomes indicated a significant effect of interaction between the growth regulator and nano-boron. Treatment $G_{75}B_{20}$ achieved the highest values, at 46.51 cm for shoot length, 41.04 mg g^{-1} FW for total chlorophyll content, and 53.86% and 41.69% for fruit set and fruit retention, respectively. Conversely, treatment G_0B_0 recorded the lowest values, at 26.61 cm for shoot length, 34.11 mg 100 g^{-1} FW for total chlorophyll content, and 39.27% and 30.19% for fruit set and fruit retention, respectively. Regarding shoot diameter, treatment $G_{25}B_{20}$ attained the highest mean of

5.06 mm, while the lowest mean of 4.91 mm was observed in treatment G_0B_0. However, there was no significant effect observed between the study factors interaction for leaf area.

Table 2: Impact of spraying with gibberellic acid, boron trioxide nanoparticles and their interaction on annual shoots length and diameter, leaf area, chlorophyll content, fruit set and fruit retention of apricot trees cv. "Zaghinia".

Treatments		Annual shoot length (cm)	Annual shoot diameter (mm)	Leaf area (cm^2)	Chlorophyll (mg 100 g^{-1} F.W.)	Fruit set (%)	Fruit retention (%)
GA_3 (mg L^{-1})	**G_0**	28.39	4.97	17.79	36.24	41.58	33.15
	G_{25}	33.83	5.01	18.18	37.86	46.74	36.35
	G_{50}	37.98	4.99	18.55	39.23	50.07	38.80
	G_{75}	44.14	4.94	19.22	40.30	51.64	39.96
L.S.D.		**2.13**	**N.S.**	**0.62**	**1.05**	**1.29**	**1.06**
Nano-Boron (mg L^{-1})	**B_0**	33.20	4.92	18.16	37.40	44.84	34.82
	B_{10}	35.98	4.98	18.46	38.50	47.28	37.19
	B_{20}	39.09	5.02	18.68	39.32	50.39	39.18
L.S.D.		**1.89**	**0.07**	**0.51**	**0.91**	**1.12**	**0.92**
G_0	**B_0**	26.61	4.91	17.41	34.11	39.27	30.19
	B_{10}	28.92	4.98	17.94	36.66	41.45	33.41
	B_{20}	29.62	5.03	18.03	37.97	44.03	35.68
G_{25}	**B_0**	29.47	4.96	17.99	36.87	42.33	33.57
	B_{10}	33.04	5.01	18.21	38.14	46.82	37.36
	B_{20}	38.98	5.06	18.35	38.58	51.07	38.12
G_{50}	**B_0**	34.52	4.93	18.40	38.95	48.47	37.46
	B_{10}	38.18	5.00	18.53	39.03	49.13	37.90
	B_{20}	41.23	5.04	18.74	39.71	52.62	41.05
G_{75}	**B_0**	42.17	4.90	18.86	39.67	49.32	38.07
	B_{10}	43.75	4.96	19.17	40.20	51.75	40.12
	B_{20}	46.51	4..98	19.63	41.04	53.86	41.69
L.S.D.		**3.79**	**0.14**	**N.S.**	**1.82**	**2.25**	**1.84**

The positive gibberellic acid effect in enhancing the annual shoot length, leaf area, and chlorophyll content (Table 2) when sprayed on apricot trees is probably ascribed to its fundamental participation in plant growth which stimulates cell elongation and expansion by increasing the plasticity and elasticity of cell walls. It also indirectly encourages cell division and enhances the enzymes activity responsible for the biosynthesis of nucleic acids and proteins, which participate in vital activities such as photosynthesis, carbohydrate metabolism, and chlorophyll synthesis. Additionally, gibberellic acid regulates the movement and distribution of nutrients and photosynthetic output towards growing points in the plant (17 and 29), which reflected positively on improving vegetative growth traits.

The effect of GA_3 spray in increasing the per cent fruit set and retention is perhaps due to its role in promoting flower formation and accumulation of endogenous auxin through inhibiting the activity of IAA-oxidase. As auxin contributes to preventing the breakdown of the abscission layer, thereby reducing flower and fruit drop (15 and 31).

The positive influence of boron nanoparticles spraying in boosting growth, as indicated by the increase in the annual shoots length and diameter, leaf area, and content of total chlorophyll (Table 2), perhaps attributed to stimulating cell division and elongation, activation of meristematic tissues, photosynthetic efficiency, nucleic acid synthesis, and auxin metabolism. Additionally, boron may contribute to the composition and regulation of cellular membranes permeability, and improve the associated enzyme activity such as peroxidase, catalase, and ATPase (33).

The increase in fruit set percentage observed with boron nanoparticle treatment perhaps attributed to its role in promoting flower initiation and development, improving the pollination process by enhancing sugar translocation to flowers, thereby increasing

nectar sugar content. Moreover, boron plays a crucial role in pollen germination and pollen tube growth, which positively affects fruit set. Additionally, boron contributes to the synthesis and metabolism of indole-3-acetic acid, thus promoting fruit retention through the auxin's role in stimulating the ovary cells division and expansion, along with preventing the formation of the abscission layer (39).

Total yield and physico-chemical traits: The outcomes in Table 3 demonstrate that the total yield of apricot trees, as well as the quantitative and qualitative fruit traits, significantly increased due to gibberellic acid treatment, especially at concentration G_{75}. This treatment achieved significant superiority by yielding the highest values, at 13.61 kg tree^{-1}, 24.54 g, 30.93 cm^{3}, and 0.242 mg 100 g^{-1} for tree yield, fruit weight and volume, and carotene content, respectively. Conversely, treatment G_0 recorded the lowest values, reaching 10.16 kg tree^{-1}, 20.02 g, 26.88 cm^{3}, and 0.120 mg 100 g^{-1}. Additionally, spraying with concentration G_{25} resulted in a significant heighten in total soluble solids and an acidity percentage decrease, which reached 14.95% and 0.88%, correspondingly, the G_0 treatment achieved the lowest fruit soluble solids content and the highest acidity percentage, reaching 14.10% and 1.19%, respectively.

The results also showed significant differences in fruit yield and its quantitative and qualitative traits due to nano-boron treatment. Treatment B_{20} significantly outperformed others, yielding the highest fruit yield, fruit weight, TSS content, and carotene content, at 13.24 kg tree^{-1}, 24.19 g, 14.82%, and 0.189 mg 100 g^{-1}, respectively. Whereas, B_0 achieved lowest values for these traits, measuring 10.85 kg tree^{-1}, 20.86 g, 14.29%, and 0.148 mg 100 g^{-1}, respectively. While the foliar nano-boron applied did not significantly impact fruit size and acidity percentage.

The results indicate significant effect of interaction between the growth regulator and nano-boron, as treatment $G_{75}B_{20}$ achieved the highest values, at 14.43 kg tree^{-1}, 25.59 g, 32.84 cm^{3}, and 0.270 mg 100 g^{-1} for fruit yield, fruit weight, fruit volume, and carotene content, respectively. Whereas, the lowest values were observed in treatment G_0B_0, which recorded 8.56 kg tree^{-1}, 17.92 g, 25.81 cm^{3}, and 0.106 mg 100 g^{-1}, respectively. Additionally, treatment $G_{25}B_{20}$ showed a notable boost in TSS content, at 15.12%, along with a significant decrease in titratable acidity percentage, at 0.81%, compared to treatment G_0B_0, which recorded percentages of 13.53% and 1.23%, respectively.

Table 3: Impact of foliar with gibberellic acid, boron trioxide nanoparticles and their interaction on fruit yield, fruit weight, fruit volume, total soluble solids, titratable acidity and carotene content of apricot trees cv. "Zaghinia".

Treatments		Yield (kg tree^{-1})	Fruit weight (g)	Fruit volume (cm^3)	TSS (%)	TA (%)	Carotene content (mg 100 g^{-1})
GA_3 (mg L^{-1})	G_0	10.16	20.02	26.88	14.10	1.19	0.120
	G_{25}	11.62	21.86	28.59	14.95	0.88	0.136
	G_{50}	13.00	23.77	29.31	14.77	1.01	0.175
	G_{75}	13.61	24.54	30.93	14.63	1.04	0.242
L.S.D.		**1.53**	**0.63**	**2.45**	**0.53**	**0.19**	**0.21**
Nano-Boron (mg L^{-1})	B_0	10.85	20.86	27.97	14.29	1.09	0.148
	B_{10}	12.20	22.58	28.65	14.73	1.01	0.168
	B_{20}	13.24	24.19	30.17	14.82	0.99	0.189
L.S.D.		**1.30**	**0.57**	**N.S.**	**0.46**	**N.S.**	**0.18**
G_0	B_0	8.56	17.92	25.81	13.53	1.23	0.106
	B_{10}	10.23	19.81	26.72	14.36	1.19	0.119
	B_{20}	11.70	22.34	28.12	14.41	1.15	0.134
G_{25}	B_0	9.40	18.67	27.35	14.76	0.98	0.123
	B_{10}	12.31	22.75	28.76	14.98	0.86	0.131
	B_{20}	13.15	24.16	29.68	15.12	0.81	0.155
G_{50}	B_0	12.45	22.90	28.97	14.50	1.05	0.151
	B_{10}	12.87	23.73	28.92	14.86	0.98	0.179
	B_{20}	13.68	24.68	30.05	14.97	1.01	0.196
G_{75}	B_0	13.02	23.98	29.76	14.38	1.12	0.213
	B_{10}	13.39	24.05	28.65	14.73	1.03	0.244
	B_{20}	14.43	25.59	30.17	14.80	0.98	0.270
L.S.D.		**2.61**	**1.15**	**4.42**	**0.92**	**0.33**	**0.37**

The increase in yield may be due to the impact of gibberellic acid in improving fruit set and retention (Table 2), as well as increasing their weight and volume, along with this could be due to the increase in leaf area and chlorophyll content, and produce a higher amount of photo-assimilates and increase the metabolites in the sink i.e. fruits. Additionally, gibberellic acid stimulates division and elongation of cells, regulates permeability of the cellular membranes, as well as enhances the activity of α-amylase enzyme, which converts starch into sugars, positively impacting fruit weight, size, and soluble solids content, while reducing the titratable acidity (17 and 29). These findings are harmonious with the results of (1, 8, 18 and 21), which demonstrated a significant increase in growth traits, yield, and fruit quality attributes following foliar spray of gibberellic acid on apricot trees.

The increase in fruit weight may be attributed to the effective role of boron in enhancing the movement and transfer of photosynthates from source to sink, furthermore to its active role in stimulating cell division and elongation (41).

The rise in total yield resulted from the increase in the fruit set and fruit retention percentage (Table 2), along with the weight of fruits (Table 3). The reason for the increase in total soluble solids can be attributed to the role of boron in the movement and translocation of carbohydrates from photosynthetic leaves to fruits, as well as its role in converting starch into monosaccharides (5). These outcomes are consistent with the findings obtained by (16) on pomegranate, (2) on mango, (26) on sweet orange, (22) on pomegranate, and (13) on date palm, where the vegetative growth traits, yield, and quantitative and qualitative fruit characteristics increased when foliar sprayed with nano-boron.

Conclusions

Based on the present study results, it was concluded that among the different concentrations of foliar spraying with gibberellic acid and nano boron trioxide, the performance of gibberellic acid (75 mg L^{-1}) and nano-boron (20 mg L^{-1}) was the best in enhancing vegetative growth traits, fruit set, fruit retention, furthermore their quantitative and qualitative characteristics.

Supplementary Materials:

No Supplementary Materials.

Author Contributions:

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