



## The Physiological Impact of Some Plant Growth Regulators and Spraying Dates on the Vegetative and Root Characteristics of Myrtle (*Myrtus communis* L.)

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### ABSTRACT

This study was conducted in the lathouse of the Department of Horticulture and Landscape Design, College of Agriculture, University of Kirkuk, Agricultural Research and Experiment Station at Al-Sayyada, during the period from September, 2024, to July 2025. The aim was to investigate the physiological effects of foliar application of different plant growth regulators, namely benzyl adenine (BA), gibberellic acid (GA<sub>3</sub>), and indole-3-butyric acid (IBA), each applied at three concentrations (0, 100, and 150 mg L<sup>-1</sup>), at two spraying dates: October 1 (first date) and November 1 (second date), with two applications for each date, on selected vegetative and floral traits of myrtle (*Myrtus communis* L.). The experiment was arranged in a Randomized Complete Block Design (R.C.B.D.) using a split-plot arrangement, with three replications and three plants per experimental unit. Data were analyzed using the SAS statistical software [1], and mean comparisons were performed using Duncan's Multiple Range Test at the 5% probability level. The results showed that The growth regulators exhibited differential physiological effects. Foliar spraying with IBA at 100 mg L<sup>-1</sup> significantly increased the number of roots (34.50 roots) and the length of the primary root (35.50 cm). IBA at 150 mg L<sup>-1</sup> significantly enhanced branch length (21.83 cm) and root dry matter percentage (45.83%). GA<sub>3</sub> at 100 mg L<sup>-1</sup> significantly increased total chlorophyll content (134.35 mg g<sup>-1</sup>), while GA<sub>3</sub> at 150 mg L<sup>-1</sup> significantly enhanced leaf number (604.67 leaves plant<sup>-1</sup>) compared with the control. Spraying dates had a clear impact, with the first date (October 1) being significantly superior for all studied traits. At this date, leaf number reached 604.81 leaves, branch length 21.57 cm, total chlorophyll content 141.87 mg g<sup>-1</sup>, root number 25.04, primary root length 31.19 cm, and root dry matter percentage 74.36%, compared with the second date (November 1). The interaction between growth regulators and spraying dates revealed significant effects. Spraying BA at 150 mg L<sup>-1</sup> on the first date significantly increased branch length (27.50 cm). GA<sub>3</sub> at 150 mg L<sup>-1</sup> on the first date significantly enhanced leaf number (682.67 leaves plant<sup>-1</sup>). IBA at 100 mg L<sup>-1</sup> led to a significant increase in root number (36.00 roots at the second date) and primary root length (36.33 cm at the first date). Moreover, IBA at 150 mg L<sup>-1</sup> significantly increased total chlorophyll content (158.94 mg g<sup>-1</sup>) and root dry matter percentage (47%). Overall, these treatments outperformed the control in most measured traits.

**Keywords:** *Myrtus communis* L., Plant growth regulators, GA<sub>3</sub>, BA, IBA Spraying date, vegetative growth, root.

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### INTRODUCTION

Myrtle plant (*Myrtus communis* L.) belongs to the family Myrtaceae, which comprises approximately 90 genera and 2,800 species. It is a familiar and desirable shrub for forming hedges in many gardens due to its lush evergreen foliage, the pleasant scent of its leaves, its aromatic flowers, and its adaptability to a wide range of climates. Its native habitat is the Mediterranean Basin. Myrtle is a slow-growing, small-sized woody evergreen shrub, reaching heights of 1–4 m. It is widely used in landscape designs and is considered one of the most attractive ornamental hedges. It can be planted individually or in groups with other shrubs, and it thrives across Iraq in various soil types, showing good drought tolerance. Woody branches become evident after pruning, and the branches are traditionally used in many religious rituals, weddings, and funerals. The plant propagates easily by hardwood cuttings and sometimes from seeds.

The leaves are simple, small, smooth, glossy, opposite, ovate to lanceolate in shape, with entire margins and acute tips, and are aromatic. The flowers are solitary, white or slightly reddish, small, and fragrant, appearing in spring. The fruits are bluish-black berries with an aromatic scent and a pleasant taste [2, 3]. The leaves, flowers, and fruits produce an essential oil known as “Angel’s Water,” characterized by a refreshing aroma and considered important in the perfume industry [4]. The leaves also contain antiseptic and anti-inflammatory compounds, useful in treating mild and hemorrhagic diarrhea, gum diseases, and oral inflammations [5]. In the food industry, the ripe fruits—rich in vitamins—are used as flavoring agents in various foods and incorporated into chewing gum formulations [6]. *Sumbul et al.* [7] reported that myrtle contains active compounds such as tannins, flavonoids, coumarins, volatile oils, glycosides, organic acids, and antioxidants. Al-Kahfagi [8] confirmed the presence of various phytochemicals in the leaves: the aqueous extract contained tannins, saponins, glycosides, flavonoids, and phenols, while the ethanolic extract contained tannins, glycosides, resins, flavonoids, and phenols.

Plant growth regulators are among the most important factors influencing physiological processes in plants by stimulating, activating, or modifying them. Indole-3-butyric acid (IBA) is one of the most effective and least phytotoxic synthetic auxins. It plays vital roles in increasing enzyme activity, altering membrane permeability, stimulating rooting, promoting root growth, increasing root hair density and vegetative growth, and inducing cell elongation through activation of mRNA and protein synthesis [9]. IBA has been shown to significantly increase rooting percentage, root number, root length, shoot length and diameter, and total carbohydrate percentage in bottlebrush (*Callistemon viminalis* L.) cuttings [10]. Similar findings were reported by [11] for snowbush (*Breyntia disticha*) and by [12] for pomegranate (*Punica granatum* L.). Cytokinins are plant hormones that promote growth after auxins and gibberellins. They play an essential role in stimulating cell division and differentiation in combination with auxins, and are important in processes such as leaf expansion and nutrient uptake [13,14]. Cytokinins stimulate lateral bud growth and branching without apical pruning, thereby increasing yield and quality traits such as early flowering and improved floral characteristics [15]. Eraki [16] found that BA application significantly increased plant height, branch number, and fresh and dry leaf weights in *Hibiscus sabdariffa* L. compared to the control. Similar effects were observed in geranium (*Pelargonium graveolens*) and calendula (*Calendula officinalis*) with BA foliar spraying, enhancing organ growth, active compound content, and total carbohydrate content, as well as improving growth and flowering in saffron (*Crocus sativus* L.) [17]. Gibberellins are among the most widely used plant hormones in agriculture, particularly in ornamentals. They have multiple physiological effects, including regulating enzymatic activity, enhancing metabolic processes such as carbohydrate synthesis, stimulating cell division and elongation, breaking dormancy, increasing stem length, increasing flower number, and promoting fruit set [18]. They promote growth by increasing cell volume, regulating cell membrane permeability, and aiding the transition from vegetative to reproductive growth. Gibberellins also influence the synthesis, transport, and perception of hormonal signals regulating plant growth and development under different environmental conditions. Young leaves, fruits, buds, and developing seeds are rich sources of these bioactive compounds, which participate in processes such as seed germination, leaf expansion, stem elongation, flowering initiation, floral organ formation, fruit development, and vegetative growth in many medicinal and ornamental plants [19,20]. They are generally classified as growth promoters, affecting physiological and biochemical responses from germination to senescence [21]. Ahmed and Al-Saad [22] reported that GA<sub>3</sub> significantly increased plant height and inflorescence stalk length in geranium (*Pelargonium sp.*) but produced the lowest number of inflorescences and had no significant effect on other traits. Previous studies have emphasized the importance of plant hormones in promoting early flowering, prolonging flower longevity, delaying senescence, stem elongation, and increasing both floral bud and flower numbers. Spraying dates play a major role in determining the effectiveness of growth regulators, affecting plant response and the degree of benefit obtained from their application. El-Yazal and Rady [23] noted that variations in spraying time can affect vegetative growth rates, flowering, and even the chemical composition of leaves, which in turn influence total productivity. The timing of application is crucial for maximizing absorption of the active substance and targeting it toward desired physiological processes. Leaf uptake is typically highest during peak physiological activity, such as active vegetative growth or early flowering, when stomata are open and metabolic activity is at its peak [24]. Differences in spraying dates can lead to substantial variation in results: early spraying may promote vegetative growth at the expense of flowering, whereas late spraying may reduce responsiveness due to decreased tissue sensitivity [25]. Based on these, the present study aimed to evaluate the effects of two spraying dates with different concentrations of plant growth regulators (IBA, GA<sub>3</sub> and BA) on the physiological and morphological traits of myrtle, and to determine the optimal spraying time for promoting good growth and improving productivity. This can contribute to developing more efficient agricultural techniques to support the cultivation of this important plant under diverse environmental conditions and to guide agricultural practices toward achieving sustainable, high-quality production under environmental challenges.

### Material and Methods:

The experiment was conducted in the lathhouse at the Agricultural Research and Experiment Station (Al-Sayyada), affiliated with the Department of Horticulture and Landscape Design, College of Agriculture, University of Kirkuk, Iraq. The study period extended from September 2024 to July 2025. The research aimed to evaluate the physiological effects of foliar application of different plant growth regulators (PGRs) — indole-3-butyric acid (IBA), gibberellic acid ( $GA_3$ ) and benzyl adenine (BA), applied at varying concentrations and dates on the vegetative and flowering traits of (*Myrtus communis* L). The plants were obtained from a local nursery in Kirkuk Governorate. The experimental area in the shade house was prepared by removing residual shrubs, cleaning, plowing, and leveling the soil to achieve a uniform surface. Plastic trays were placed under the pots to retain applied materials, prevent loss, and reduce weed growth. Subsequently, the pots intended for planting and transplanting the seedlings were filled with a growing medium composed of (2 parts loam: 1 part peat moss). A sample of this medium was taken after mixing and before planting for laboratory analysis of its chemical and physical properties (Table 1). Seedlings were transplanted on September 13, 2024, from 10 cm diameter plastic pots into larger plastic pots with a diameter of 20 cm and a capacity of 6.5 kg of the growing medium. Plants were irrigated regularly as needed. A weekly protective program was applied, consisting of a fungicide (Sky-720WP) containing 64% Mancozeb + 8% Metalaxyl, and an insecticide (Pure Plus) with the active ingredient Chlorpyrifos Lambda-cyhalothrin 415 g/L EC, sprayed on the foliage as a preventive measure against fungal and insect pathogens, following the recommendations of [26]. Weed growth was monitored and removed whenever necessary. All plants were fertilized monthly with a balanced compound fertilizer (N:P:K 20:20:20) at a rate of 2 g pot<sup>-1</sup>.

Table (1): Physical and chemical properties of the mixture before cultivation.

Type of analysis	Standard unit	loam	loam + Peat moss
EC	ms. cm <sup>-1</sup>	0.063	0.189
pH	-	8.20	7.32
TDS	mg kg <sup>-1</sup>	40.384	121.152
Total nitrogen	mg kg <sup>-1</sup>	854.268	1195.975
Available Phosphorus	mg kg <sup>-1</sup>	0.593	6.001
Available Potassium	mg kg <sup>-1</sup>	46.803	90.264
Organic matter	%	0.345	1.518
Lime	%	34,490	33,560
Texture	-	Sandy loam	Sandy loam
Clay	%	4	4
Silt	%	12	26
Sand	%	84	70

\* The soil was analyzed in the soil laboratory of the Kirkuk Agriculture Directorate.

### Readings were taken for vegetative and root characteristics at the flowering stage, and the characteristics studied included the following:

Increase rate in number of leaves <sup>1</sup>plant<sup>-1</sup>, the rate of increase in branch length (cm), Total chlorophyll content (mg g<sup>-1</sup> fresh Weight), number of roots <sup>1</sup>plant<sup>-1</sup>, main root length (cm.plant<sup>-1</sup>), and root dry matter percentage (%). Data were analyzed using SAS software [1], and (Duncan's Multiple Range Test) was applied at a probability level of 0.05 [27].

### Results and discussion:

#### 3.1. Increase rate in the number of leaves plant<sup>-1</sup>:

The results in Table (2) show a significant effect of plant growth regulators, spraying dates, and their interaction on the rate of increase in the number of leaves per plant of myrtle (*Myrtus communis* L.). Foliar application of  $GA_3$  at 150 mg L<sup>-1</sup> was significantly superior, giving the highest increase in leaf number (604.67 leaves·plant<sup>-1</sup>), and differed significantly only from IBA at 100 mg L<sup>-1</sup> and the control plants, which recorded the lowest value (300.33 leaves·plant<sup>-1</sup>). Regarding spraying dates, the first date (October 1) was significantly superior, with the highest mean (604.81 leaves·plant<sup>-1</sup>), compared to the second date (November 1), which gave the lowest value (424.57 leaves·plant<sup>-1</sup>). This indicates that early spraying coincides with the onset of physiological activity in the plant, allowing growth regulators to exert a stronger influence on cell division and elongation before the plant enters advanced growth stages. The interaction between the two factors revealed that  $GA_3$  at 150 mg L<sup>-1</sup> applied on the first date resulted in the highest mean (682.67 leaves·plant<sup>-1</sup>), significantly surpassing only the control treatment, which recorded the lowest value (224.00 leaves·plant<sup>-1</sup>) on the second date (November 1). No significant differences were observed among the other treatments at the first date. The superiority of  $GA_3$  and other growth regulators is attributed

to their physiological roles in stimulating cell division and elongation, thereby increasing leaf area through the enhancement of leaf bud formation and improving photosynthetic efficiency. Gibberellic acid in particular plays a crucial role in breaking dormancy, promoting longitudinal and lateral leaf growth, and increasing leaf area [24].

Table (2): Physiological impact of some plant growth regulators, spraying dates, and their interaction On the Increase rate of the number of leaves per plant of myrtle plants (*Myrtus communis* L.).

Concentration PGRs (mg L <sup>-1</sup> )	Spray dates		Mean of growth regulators
	First date (1/10)	Second date (1/11)	
Control	373.67 g	227.00 h	300.33 c
IBA 100	582.67 abcd	347.67 g	465.17 b
IBA 150	632.67 abc	494.33 def	563.50 a
BA 100	659.00 a	424.67 efg	541.83 a
BA 150	647.33 ab	406.67 fg	527.00 ab
GA <sub>3</sub> 100	655.67 ab	545.00 bcd	600.33 a
GA <sub>3</sub> 150	682.67 a	526.67cde	604.67 a
Mean of spraying dates	604.81 a	424.57 b	General average of the trait $\bar{x}$ = 514.69

\*The averages with similar letters for each factor separately and their interactions did not differ significantly according to Duncan's multiple range test at the 5% probability level

Moreover, early spraying provided the plants with a longer period to benefit from hormonal effects before being exposed to environmental factors that may restrict growth. These findings are consistent with [28], who reported that gibberellic acid application at early growth stages increases leaf number by stimulating cell division in the apical meristems, as also confirmed by [22, 25], who emphasized that the interaction between hormone type and appropriate spraying time is a decisive factor in achieving the highest physiological response.

### 3.2. The rate of Increase in branch length (cm):

The results presented in Table (3) indicate that plant growth regulators, spraying dates, and their interaction had a significant effect on the increase in branch length of myrtle (*Myrtus communis* L.). Foliar application of GA<sub>3</sub> at 150 mg L<sup>-1</sup> resulted in the highest significant increase (21.83 cm), which did not differ significantly from GA<sub>3</sub> at 100 mg L<sup>-1</sup> (20.25 cm) or BA at 150 mg L<sup>-1</sup> (17.6 cm), compared to the control treatment that recorded the lowest mean (12.00 cm). This increase may be attributed to the effective role of auxins in stimulating cell division and elongation through increasing cell wall plasticity by activating expansin enzymes, in addition to enhancing carbohydrate translocation towards the growing organs [24], as well as the roles of the other growth regulators mentioned. Regarding spraying dates, the first date (October 1) was significantly superior (21.57 cm) compared to the second date (November 1), which recorded the lowest mean (11.76 cm). This can be attributed to the fact that early spraying allows plants a longer period to benefit from the hormonal effects before the decline of optimal environmental conditions for growth. Furthermore, the timing of application coincides with the active stage of apical meristems, thus enhancing the physiological response [28]. As for the interaction between the two factors, BA at 150 mg L<sup>-1</sup> applied on the first date (October 1) achieved the highest mean branch length (27.50 cm), reflecting the role of cytokinins in stimulating cell division, increasing the number of nodes, and consequently promoting both the number and length of lateral branches, particularly under favorable early-season environmental conditions. In contrast, BA at 100 mg L<sup>-1</sup> and GA<sub>3</sub> at 150 mg L<sup>-1</sup> applied at the second date recorded the lowest value (6.16 cm). These results are consistent with [29].

Table (3): Physiological impact of some plant growth regulators, spraying dates, and their interaction on the increase rate of branch length (cm) of myrtle plants (*Myrtus communis* L.).

Concentration PGRs (mg L <sup>-1</sup> )	Spray dates		Mean of growth regulators
	First date (1/10)	Second date (1/11)	
Control	12.33 de	11.66 de	12.00 c
IBA 100	19.50 bc	14.66 cd	17.08 ab
IBA 150	25.00 ab	18.66 bcd	21.83 a
BA 100	22.50 ab	6.16 e	14.33 bc
BA 150	27.50 a	6.83 e	17.16 ab
GA <sub>3</sub> 100	22.33 ab	18.16 bcd	20.25 a
GA <sub>3</sub> 150	21.83 ab	6.16 e	14.00 bc
Mean of spraying dates	21.57 a	11.76 b	General average of the trait $\bar{x}$ = 16.66

\*The averages with similar letters for each factor separately and their interactions did not differ significantly according to Duncan's multiple range test at the 5% probability level.

### 3.3. Total chlorophyll content (mg g<sup>-1</sup> fresh weight):

The results presented in Table (4) indicate that plant growth regulators and spraying dates significantly affected the total chlorophyll content of myrtle (*Myrtus communis* L.). Foliar application of GA<sub>3</sub> at 100 mg L<sup>-1</sup> recorded the highest mean value (134.35 mg g<sup>-1</sup>), compared to BA at 150 mg L<sup>-1</sup>, which gave the lowest relative value (123.80 mg g<sup>-1</sup>), with no significant differences observed among the treatments. Regarding spraying dates, the first date (October 1) significantly outperformed the second date (November 1), with mean values of 141.87 mg g<sup>-1</sup> and 115.74 mg g<sup>-1</sup>, respectively. This indicates that early spraying enhanced photosynthetic activity by improving chlorophyll formation. As for the interaction between the two factors, IBA at 150 mg L<sup>-1</sup> applied at the first date achieved the highest mean (158.94 mg g<sup>-1</sup>), compared to the same treatment at the second date, which recorded the lowest value (101.48 mg g<sup>-1</sup>). According to [30], the use of IBA improved leaf growth and increased chlorophyll content by enhancing nutrient uptake efficiency, while [31] confirmed that auxins regulate gene expression associated with chloroplast formation, thereby contributing to higher total chlorophyll content.

Table (4): Physiological impact of some plant growth regulators, spraying dates, and their interaction on total chlorophyll content of myrtle plants (*Myrtus communis* L.).

Concentration PGRs (mg L <sup>-1</sup> )	Spray dates		Mean of growth regulators
	First date (1/10)	Second date (1/11)	
Control	152.13 ab	110.08 cd	131.10 a
IBA 100	134.51 abc	118.74 cd	126.62 a
IBA 150	158.94 a	101.48 d	130.20 a
BA 100	136.83 abc	123.81 bcd	130.31 a
BA 150	133.41 abc	114.20 cd	123.80 a
GA <sub>3</sub> 100	139.95 abc	128.76 abcd	134.35 a
GA <sub>3</sub> 150	137.39 abc	113.12 cd	125.25 a
Mean of spraying dates	141.87 a	115.74 b	General average of the trait $\bar{x}$ = 128.80

\*The averages with similar letters for each factor separately and their interactions did not differ significantly according to Duncan's multiple range test at the 5% probability level.

3.4. Number of roots. plant<sup>-1</sup>

Table (5) shows the effect of plant growth regulators, spraying dates, and their interaction on the number of roots of myrtle (*Myrtus communis* L.). Foliar application of IBA at 100 mg L<sup>-1</sup> recorded the highest mean (34.50 roots), which differed significantly from the control treatment that gave the lowest value (16.00 roots). This effect may be attributed to indole-3-butyric acid (IBA) being one of the most effective auxins in inducing adventitious root formation by enhancing cell division and elongation in the root elongation zone, as reported by [28]. Thus, IBA had the greatest impact on improving rooting traits. Regarding the effect of spraying dates, significant differences were observed, with the first spraying date (October 1) achieving, the highest mean (25.04 roots) compared to the second date (November 1), which recorded 22.85 roots. The interaction between growth regulators and spraying dates revealed that IBA at 100 mg L<sup>-1</sup> applied on the second date (November 1) achieved the highest mean (36.00 roots), without significant differences from other IBA concentrations. Meanwhile, the control treatment recorded the lowest value (15.00 roots) at the second date. These findings are consistent with [28,32], who reported that auxins, particularly IBA, are the most effective in enhancing rooting in woody and semi-woody plants, compared to cytokinins (BA) and gibberellins (GA<sub>3</sub>), which often have limited or indirect effects on rooting. Similarly, [33] indicated that auxin significantly outperformed other regulators, producing the highest number of roots.

Table (5): Physiological impact of some plant growth regulators, spraying dates, and their interaction on the Number of roots plant<sup>-1</sup> of myrtle plants (*Myrtus communis* L.).

Concentration PGRs (mg L <sup>-1</sup> )	Spray dates		Mean of growth regulators	
	First date (1/10)	Second date (1/11)		
Control	31.66 abc	27.00 cd	29.33 bcd	
IBA 100	36.33 a	34.66 ab	35.50 a	
IBA 150	32.33 abc	32.00 abc	32.16 ab	
BA 100	31.66 abc	30.00 bcd	30.83 bc	
BA 150	31.66 abc	30.66 bc	31.16 bc	
GA <sub>3</sub> 100	27.00 cd	24.66 d	25.83 d	*The
GA <sub>3</sub> 150	27.66 cd	27.66 cd	27.66 cd	
Mean of spraying dates	31.19 a	29.52 a	General average of the trait $\bar{x}$ = 30.35	

averages with similar letters for each factor separately and their interactions did not differ significantly according to Duncan's multiple range test at the 5% probability level.

## 3.5. Main root length (cm):

The results in Table (6) demonstrate the effect of plant growth regulators, spraying dates, and their interaction on the main root length of myrtle (*Myrtus communis* L.). The mean root length increased significantly with foliar application of IBA at 100 mg L<sup>-1</sup>, which recorded the highest value (35.50 cm), while GA<sub>3</sub> at 100 mg L<sup>-1</sup> gave the lowest value (25.83 cm). This finding highlights the role of auxins in stimulating root growth, in contrast to gibberellic acid (GA<sub>3</sub>), which mainly promotes shoot and aerial organ elongation and may direct resources toward vegetative growth at the expense of root development. Regarding spraying dates, no significant differences were observed, although the first date (October 1) recorded a relatively higher mean (31.19 cm) compared with the second date (November 1), which gave the lowest mean (29.52 cm). The interaction effect showed significant differences, with IBA at 100 mg L<sup>-1</sup> applied at the first date producing the greatest root length (36.33 cm), while GA<sub>3</sub> at 100 mg L<sup>-1</sup> applied at the second date resulted in the lowest value (24.66 cm). This superiority can be attributed to the pivotal role of auxin (IBA) in stimulating cell division and elongation within the root elongation zone, thereby increasing root length [34]. Moreover, its positive effect on adventitious root formation and vascular cambium activity contributes to enhanced longitudinal root growth [25]. Similar studies on ornamental and medicinal plants have shown that treatment with moderate concentrations of IBA leads to significant increases in root length compared to untreated control plants [35].

Table (6): Physiological impact of some plant growth regulators, spraying dates, and their interaction on main root length (cm) of myrtle plants (*Myrtus communis* L.).

Concentration PGRs (mg L <sup>-1</sup> )	Spray dates		Mean of growth regulators
	First date (1/10)	Second date (1/11)	
Control	26.83 ef	21.50 f	24.16 e
IBA 100	42.70 abc	39.83 abcd	41.26 ab
IBA 150	47.16 a	44.50 ab	45.83 a
BA 100	32.03 de	31.86 de	31.95 cd
BA 150	34.40 de	27.80 ef	31.10 d
GA <sub>3</sub> 100	39.13 cd	34.43 de	36.78 bc
GA <sub>3</sub> 150	34.96 cde	36.33 cd	35.65 cd
Mean of spraying dates	36.74 a	33.75 b	General average of the trait $\bar{x}$ = 35.25

\*The averages with similar letters for each factor separately and their interactions did not differ significantly according to Duncan's multiple range test at the 5% probability level

### 3.6. Percentage of root dry matter (%):

The results presented in Table (7) show the effect of plant growth regulators, spraying dates, and their interaction on the root dry matter percentage of myrtle (*Myrtus communis* L.). Foliar application of IBA at 150 mg L<sup>-1</sup> had a significant effect, producing the highest value (45.83%), compared to the control plants which recorded the lowest value (24.16%). According to [36], auxins stimulate the formation of secondary roots and increase plant dry mass by enhancing nutrient uptake. Regarding spraying dates, the first date (October 1) recorded the highest percentage (36.74%), compared with the second date (November 1), which gave the lowest value (33.75%). For the interaction effect, IBA at 150 mg L<sup>-1</sup> applied at the first date (October 1) significantly outperformed all other treatments, achieving the highest dry matter percentage (47.16%), while the lowest value (21.50%) was recorded in the control treatment at the second date (November 1). This reflects the high efficiency of IBA in stimulating carbohydrate deposition in the roots and its role in increasing dry matter accumulation. These findings are consistent with [28], who reported that auxins accelerate cell division and elongation in the root zone and enhance the deposition of photosynthetic products, thereby improving root growth. Furthermore, [37] indicated that growth regulators contribute to redirecting carbohydrate flow toward storage organs, leading to an increase in root biomass.

Table (7): Physiological impact of some plant growth regulators, spraying dates, and their interaction on Percentage root dry matter (%) of myrtle plants (*Myrtus communis* L.).

Concentration PGRs (mg L <sup>-1</sup> )	Spray dates		Mean of growth regulators
	First date (1/10)	Second date (1/11)	
Control	17.00 cd	15.00 d	16.00 c
IBA 100	33.00 a	36.00 a	34.50 a
IBA 150	33.66 a	30.66 a	32.16 a
BA 100	24.00 b	22.66 bc	23.33 b
BA 150	22.66 bc	16.00 d	19.33 bc
GA <sub>3</sub> 100	23.66 b	21.00 bcd	22.33 b
GA <sub>3</sub> 150	21.33 bcd	18.66 bcd	20.00 bc
Mean of spraying dates	25.04 a	22.85 b	General average of the trait $\bar{x}$ = 23.95

\*The averages with similar letters for each factor separately and their interactions did not differ significantly according to Duncan's multiple range test at the 5% probability level.

## Conclusions

The results indicate a significant effect of the different plant growth regulators on most of the vegetative and root traits compared with the control plants, with variations in their physiological influence. Foliar application of IBA significantly enhanced branch length increment, total chlorophyll content, number of roots, main root length, and root dry matter percentage. Gibberellic acid (GA<sub>3</sub>) had a significant effect on increasing the number of leaves and total chlorophyll content, while benzyl adenine (BA) significantly increased the number of leaves and improved branch length. Furthermore, spraying at the first date (October 1) significantly outperformed the second date in most vegetative and root traits.

## References

- [1]. SAS Institute. 2002. The SAS system for Windos v. 9.00 SAS Institute Inc., Cary, NC. USA.
- [2]. Al-Sultan, S. M., Al-Jalabi, T. M., & Al-Sawwaf, M. D. (1992). *Ornamentals*. Mosul: Dar Al-Kutub for Printing and Publishing, Ministry of Higher Education and Scientific Research.
- [3]. Al Saad, K. G. 2024. *Ornamental Plants*, First Edition, Ministry of Higher Education and Scientific Research, Kirkuk University, College of Agriculture, ISBN: 978\_9922\_8376\_0\_4.
- [4]. Boelense, M. H. and Jimenez, R., 1992. The chemical composition of Spanish
- [5]. Akalu, N., Endale, A. and Asres, K. 2007.. Evaluation of Antimicrobial Activity of the Essential Oil of *Myrtus communis* L. and Its Formation into Gum Paint. *Ethiopian Pharmaceutical Journal*. Vol. 25, No. 1, pp. 72-76.
- [6]. Akin, M., Aktumsek, A. and Nostro, A. 2010. Antibacterial activity and composition of the essential oils of *Eucalyptus camaldulensis* Dehn. and *Myrtus communis* L. growing in Northern Cyprus. *African Journal of Biotechnology*. Vol. 9(4), pp. 531-535.
- [7]. Sumbul, S., Ahmed, M. A., Asif, M. and Akhtar, M. 2011.. *Myrtus communis* Linn. - A review. *Ind. J. Nat. Prod. Resources*, 2(4): 395-402. Ereeş, F. S., Aközcan, S., Parlak, Y., & Cam, S. (2006). Assessment of dose rates around Manisa (Turkey). *Radiation Measures*, 41(5), 598-601.
- [8]. Al-Kahfagi, Huda S. A. R. 2016. The effects of attractants and repelleants for some plants extracts to houseflies *Musca domestica* (Diptera : Muscidae)
- [9]. Abdel-Rahman, S. S. 2020. Influence of rooting media and indole-3- butyric acid (IBA) concentration on rooting and growth of different types of *Conocarpus erectus* L. stem cuttings. *Scientific Journal of and Flowers Ornamental Plants*, 7(3), 199-219
- [10]. Mustafa, F. I. and Al-Sayed, H. M. 2021. Growth Biostimulants as Synthetic Hormone Replacements for Rooting, Vegetative Growth and Chemical Constitutions Promotion in Rose Cuttings Under Different Growing Media *Assiut Journal of Agricultural Sciences* 54(2) (73-90).
- [11]. El-Banna, H., Haroun, S. A., Albishi, T. S., Rashed, A. A., Albadrani, M., Abdelaal, K., & Abdou, A. H. 2023. The Natural Alternatives: The Impact of Plant Extracts on Snowbush (*Breynia distich* Forst.) Cuttings' Morpho-Physiological and Biochemical Characteristics. *Horticulturae*, 9(10), 1122.
- [12]. Mahdi S. M. 2024. The effect of some plant extracts and indole butyric acid on the rooting and growth of cuttings of two population varieties (*Punica granatum* L.). Master Thesis. University of Karbala - College of Agriculture
- [13]. Hassan, E. A. and El-Quesni, F. M. 1989. Application of growth regulators in agriculture. A cytokinin induced new morphogenetic phenomenon in carnation (*Dianthus caryophyllus* L.). *Bull. Fac. Agric, Cairo Univ.*, 40, 187-196.
- [14]. Shudok, K. 1994. Chemistry of Phenylurea Cytokinins. In *Cytokinins: Chemistry, activity and function*.
- [15]. Subbaraj, A. K., Funnell, K. A. & Woolley, D. J. (2010). Dormancy and Flowering are regulated by the recursive in correction between cytokines and gibberellin in *Zantedeschia* time for a change *Trends Genet.* (11): 263-268.
- [16]. Eraki, M. A. 1994. Effect of benzyl adenine (BA) application on the growth, fruit yield and some chemical constants of *Hibiscus sabdariffa* L. plants. *Minofiya J. Agric. Res.*, 2, 623-637.
- [17]. Al-Zubaidi, M. M. O. and Al-Saad, K. G. S. 2019. Effect of Benzyl Adenine on Growth and Flowering of Some Saffron (*Crocus sativus* L.) Cultivars *J. of Kirkuk Univ. for Agri. Sci.* Vol. (12) No. (2) 2021 Appendix.
- [18]. Al-Khafaji, M. A. 2014. *Plant Growth Regulators, Their Horticultural Applications and Uses*. Ministry of Higher Education and Scientific Research. University of Baghdad. College of Agriculture.
- [19]. Taiz, L. and E. Zeiger. 2010. *Plant Physiology*. *Phytochem. Anal.* 31(6): 778-785. <https://www.sinauer.com/media/wysiwyg/tocs/PlantPhysiology5.pdf>.
- [20]. Colebrook, E. H., Thomas, S. G., Phillips, A. L. and Hedden, P. 2014. The role of gibberellin signing in

- plant responses to abiotic stress. *J. Exp. Biol.* 217(1): 67-75. :<https://doi.org/10.1242/jeb.089938>
- [21]. Li, Z., Pei, X., Yin, S., et al., 2019. Plant hormone treatments to alleviate the effects of salt stress on germination of *Betula platyphylla* seeds. *J. For.Res.* 30, 779–787.
- [22]. Ahmed, S. B. H., and Al-Saad, K. G. S. 2018. Effect of Thiamine and Gibberellic acid on growth and flowering of *Geranium* (*Pelargonium* sp.) College of Agriculture - University of Kirkuk, III. International Scientific Conference for Agricultural Sciences \_ p. 425. Iraq.
- [23]. El-Yazal, M. A., and Rady, M. M. 2019. Effect of growth regulators on plant growth and development: A review. *Journal of Plant Growth Regulation*, 38(2), 329-347.
- [24]. Taiz, L. and Zeiger, E. 2015. *Plant Physiology and Development* (6th ed.). Sinauer Associates.
- [25]. Davies, P. J. 2010. *Plant Hormones: Biosynthesis, Signal Transduction, Action!* Springer.
- [26]. Al-Saad, K. G. S. 2010. The effect of planting dates, gibberellic acid, and licorice Root extract on growth and yield of (*Gladiolus hybrida*) . PhD thesis. University of Mosul. College of Agriculture and Forestry. Iraq.
- [27]. Al-Zubaidi, K. M. D. and Al-Jubory, K. K. A. 2016. *Design and Analysis of Genetically Experiments*. Dar Al Wadah for Publishing, Jordan, Amman, Dijla Bookshop for Printing, Publishing and Distribution, Iraq – Baghdad.
- [28]. Hartmann, H. T., Kester, D. E., Davies, F. T. and Geneve, R. L. 2014. *Plant propagation: Principles and practices* (8th ed.). Pearson.
- [29]. Ali, H. H., Khalaf, J. M. and Noori, A. M. 2024. In vitro Propagation of pomegranate (*Punica granatum* L.). *Kirkuk University Journal for Agricultural Sciences*. ISSN:2958-6585. <https://doi.org/10.58928/ku24.15129>.
- [30]. Ashraf, A. M., et al. 2022. Auxin-mediated regulation of chlorophyll biosynthesis and photosynthetic performance. *Frontiers in Plant Science*.
- [31]. Niu, Y., et al. 2016. Auxin regulates chloroplast development through gene expression control in *Arabidopsis*. *Journal of Experimental Botany*.
- [32]. Sharma, N., Singh, K. and Kumar, R. 2018. Effect of auxins on rooting of hardwood cuttings in woody plants: A review. *Journal of Pharmacognosy and Phytochemistry*, 7(5), 323–329.
- [33]. Kamal, T. F., Al-Saad, K. G. and Noori, A. M. 2024. Influence of Auxins and different growth media strength on rooting of *Petunia hybrida* L. In vitro Propagation. *Kirkuk University Journal for Agricultural Sciences*. ISSN:2958-6585. <https://doi.org/10.58928/ku24.15315>.
- [34]. Hartmann, H. T., Kester, D. E., Davies, F. T. and Geneve, R. L. 2011. *Plant Propagation: Principles and Practices*. 8th ed. Prentice Hall.
- [35]. Abdel-Rahman, M., El-Sherif, M. and El-Nashar, Y. 2017. Effect of IBA on rooting and growth of ornamental plants. *Journal of Horticultural Science*, 89(2), 145-152.
- [36]. Abdullah, R., Iqbal, M., Ahmad, I. and Hussain, S. 2020. Auxins mediated root induction and growth responses in ornamental plants. *International Journal of Botany Studies*, 5(3), 45–52.
- [37]. Taiz, L., Zeiger, E., Møller, I. M. and Murphy, A. 2015. *Plant physiology and development* (6th ed.). Sunderland, MA: Sinauer Associates.

## التأثير الفسلجي لبعض منظمات النمو النباتية وموعد الرش في بعض الصفات الخضرية والجذرية لنبات الآس (*Myrtus communis L.*)

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### الخلاصة

أجريت هذه الدراسة في الظلة الخشبية التابعة لقسم البستنة وهندسة الحدائق / كلية الزراعة / جامعة كركوك / محطة البحوث والتجارب الزراعية / الصيادة ، للفترة من أيلول 2024 ولغاية تموز 2025، بهدف دراسة التأثير الفسلجي للرش الورقي بمنظمات النمو النباتية المختلفة : ( بنزيل أدينين (*BA*) وحمض الجبريليك (*GA3*) واندول بيوتريك اسيد (*IBA*) ) ، بتراكيز مختلفة لكل منها: (0، 100، 150) ملغم /لتر-1، وموعد الرش: ( الموعد الأول)الأول من شهر تشرين الأول،(الموعد الثاني ) الأول من شهر تشرين الثاني، وبواقع رشتين لكل موعد ، في بعض صفات النمو الخضرية والجذرية لنبات الآس (الباس )، صممت التجربة وفق تصميم القطاعات العشوائية الكاملة في القطع المنشقة (*Randomized Completely Block Design (R.C.B.D.)* بثلاث مكررات، وثلاث نباتات في الوحدة التجريبية لكل معاملة ، وحلت البيانات باستخدام البرنامج الإحصائي [ *SAS* ] 1، واعتماد اختبار دنكن متعدد الحدود *Duncan's Multiple Range Test* لمقارنة بين المتوسطات عند مستوى احتمالية 5% ، وأظهرت النتائج ما يلي:

1. أظهرت منظمات النمو النباتية المختلفة تأثيراً فسلجياً متبايناً ، فقد اثر الرش الورقي بال *IBA* عند التركيز 100 ملغم . لتر-1 معنوياً في معدل عدد الجذور وبلغ فيه 34.50 جذور وطول الجذر الرئيسي 35.50 سم ، اما الرش بالتركيز 150 ملغم . لتر-1 فقد زاد معنوياً طول الافرع 21.83 سم ونسبة المادة الجافة % 45.83، اما الرش بحامض الجبريليك بالتركيز 100 ملغم . لتر-1 اثر معنوياً في المحتوى الكلورفيل الكلي وبلغ 134.35 ملغم .غم-1 ، اما الرش بالتركيز 150 ملغم . لتر-1 فقد زاد معنوياً معدل الزيادة في عدد الاوراق 604.67 ورقة نبات-1 ، مقارنة بنباتات معاملة المقارنة .

2. تفوق الرش في الموعد الاول (10/1) معنوياً في غالب الصفات الخضرية والجذرية ، فقد ازداد فيه معدل الزيادة في عدد الاوراق وطول الافرع ومحتوى الكلوروفيل الكلي وعدد الجذور وطول الجذر الرئيسي ونسبة المادة الجافة في الجذور وبلغ ( 604.81 ورقة ، 21.57 سم ، 141.87 ملغم .غم-1 ، 25.04 جذراً ، 31.19 سم ، 36.74 % ) على التوالي ، مقارنة مع نباتات في الموعد الثاني (11/1).

3. أشار التداخل الثنائي بين منظمات النمو وموعد الرش الى زيادة معنوية عند الرش بالبنزل ادنين ( *BA* ) بتركيز 150 ملغم . لتر-1 في معدل الزيادة في طول الافرع 27.50 سم في الموعد الأول ، اما الرش بحامض الجبريليك *GA3* بتركيز 150 ملغم . لتر-1 قد زاد معنوياً في معدل الزيادة في عدد الاوراق 682.67 ورقة نبات-1 في الموعد الأول ، والرش بالاندول بيوتريك اسد ( *IBA* ) بالتركيز 100 ملغم . لتر-1 أدى الى تفوق معنوي في الموعد الأول في عدد الجذور واعطى 36.00 جذر في الموعد الثاني وطول الجذر الرئيسي 36.33 سم في الموعد الأول ، اما الرش *IBA* بالتركيز 150 ملغم . لتر-1 كان له الأثر المعنوي في محتوى الكلوروفيل الكلي وبلغ 158.94 ملغم .غم-1 ونسبة المادة الجافة في الجذور % 47 ، وتفوقوا بذلك في غالب الصفات على نباتات معاملة مقارنة .

الكلمات المفتاحية: *Myrtus communis L.*، منظمات النمو النباتية، *GA3*، *BA*، *IBA*، موعد الرش، النمو الخضرية، التجذير.