The Effect of Shading and Spraying with Gibberellin and Their Interaction on Vegetative and Floral Characteristics of Jasmine Plant in Nurseries of Salah Al-Din Governorate

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Abstract

The aim of this study was to investigate the effect of shading at four levels (0%, 30%, 50%, 70%) and spraying with gibberellin at four concentrations (0, 50, 100, 150 $mg.L^{-1}$) and their interaction on the vegetative and floral traits of the jasmine plant grown in the nurseries of Salah al-Din Governorate during the agricultural season 2024-2025. The experiment was carried out according to the design of the completely randomized blocks with three replicates. The results showed that the 50% shading level was significantly superior in all the studied traits, and the gibberellin concentration of 100 $mg.L^{-1}$ outperformed the rest of the concentrations. The interaction effect recorded that the double treatment (50% shading + 100 $mg.L^{-1}$) achieved the highest values for plant height (57.6 cm), number of leaves (33.5 leaves), leaf area (10.5 cm^2), dry weight (21.3 g), number of full flowers (21.3 flowers), flower diameter (3.48 cm), calyx length (1.68 cm), and flower shelf life (11.2 days), achieving improvement rates ranging from 88% to 238% compared to the control treatment. The research recommended the adoption of 50% shading with spraying gibberellin at a concentration of 100 $mg.L^{-1}$ to improve the productivity and quality of the jasmine plant under the conditions of Salah al-Din Governorate, and to conduct future studies that include additional physiological measurements.

Keywords: Jasmine, Shading, Gibberellin, Vegetative and Floral Qualities, Interaction.

Introduction

The jasmine plant is one of the most prominent flowering plants of economic and aromatic importance in Iraq and the Arab region, as it is characterized by its fragrant white flowers that are used in the manufacture of perfumes and cosmetics, in addition to its medicinal and decorative uses. The nurseries of Salah al-Din governorate constitute a suitable agricultural environment for the production of this plant due to the prevailing climatic conditions characterized by high heat in

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summer and moderate cold in winter. However, the current production of jasmine in these nurseries suffers from a clear deficiency in its quantity and quality, and this is related to several environmental and agricultural factors, foremost of which is the intensity of solar radiation and the high temperatures during the hot seasons [2].

The jasmine plant (Jasminum spp.) belongs to the family Oleaceae, which includes about 25 genera and approximately 600 species of flowering plants. Other important members of this family include Olea europaea (olive), Syringa vulgaris (lilac), Forsythia spp., and Ligustrum spp. (privet). Studies on related species within the Oleaceae family have demonstrated shared physiological responses to environmental stressors and growth regulators. For instance, research on olive trees has shown that moderate shading improves leaf water status and chlorophyll content under high radiation conditions [16], which parallels the responses observed in jasmine. Similarly, studies on Syringa species have confirmed that gibberellin application promotes flowering and vegetative growth in woody ornamental plants belonging to this family [23]. Tahery and Panahandeh [29] reported that the interactive effects of light intensity and gibberellin on container-grown ornamentals were consistent across multiple species within the Oleaceae family. These shared characteristics within the family provide a strong scientific basis for investigating the combined effects of shading and gibberellin on jasmine, as the physiological mechanisms underlying growth regulation are likely to be conserved across related species.

Plant growth regulators play a pivotal role in regulating the growth and development processes of plants, the most prominent of which is gibberellin, which is known for its effective effects in stimulating cell and stem elongation and promoting cell division, as well as its influential role in the flowering process and the transition from the vegetative stage to the flowering stage. Studies have shown that treatment with gibberellin contributes to the improvement of a number of vegetative traits such as plant height, leaf area, and dry weight, in addition to its role in increasing the number of flowers and improving their morphological qualities [22]. However, the mechanism of action of gibberellin is affected by several environmental factors, including the intensity of light falling on the plant, which makes the study of the interaction between gibberellin and light conditions an urgent scientific necessity.

On the other hand, shading is one of the important agricultural practices used in environmental nurseries in order to alleviate the heat and

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radiation stress to plants, especially during hot summer periods. The degree of shading directly affects a range of biophysiological processes, most notably photosynthesis, gas exchange, and growth-related enzyme activities [8]. Previous studies have shown that moderate shading levels achieve positive results in promoting vegetative growth and improving flower quality in many ornamental plants, while high levels of shading lead to a decline in plant performance due to limited light energy available for photosynthesis.

It is worth mentioning that the effects of both shading and gibberellin may not be separate, but their effects overlap in complex ways depending on the nature of the interaction between them, as gibberellin is one of the regulators whose signaling chains are linked to the photoperception system of the plant [10]. Therefore, a thorough understanding of the nature of the interaction between these two factors helps in formulating accurate agricultural recommendations that contribute to improving the productivity of the jasmine plant. The need to study this interaction is that the results obtained may vary depending on the plant species and the surrounding environmental conditions [1].

In addition, agricultural nurseries in Salah al-Din governorate often lack applied studies that address the impact of double coefficients of growth regulators and improved environmental conditions on flowering plants, creating a knowledge gap that needs to be filled through systematic scientific research. The economic importance of the jasmine plant is not limited to its use in ornaments, but extends to the manufacture of perfumes, cosmetics, and herbal medicines, making it a crop with a lucrative financial return [7]. Statistics indicate that the demand for jasmine flowers in the local markets is steadily increasing, which necessitates the need to develop production methods and improve the quality of plant output. Based on the above, the present research seeks to make a tangible scientific contribution by studying the effect of shading and spraying with gibberellin and their interaction on the vegetative and floral traits of the jasmine plant under the conditions of nurseries in Salah al-Din governorate.

Material and Methods

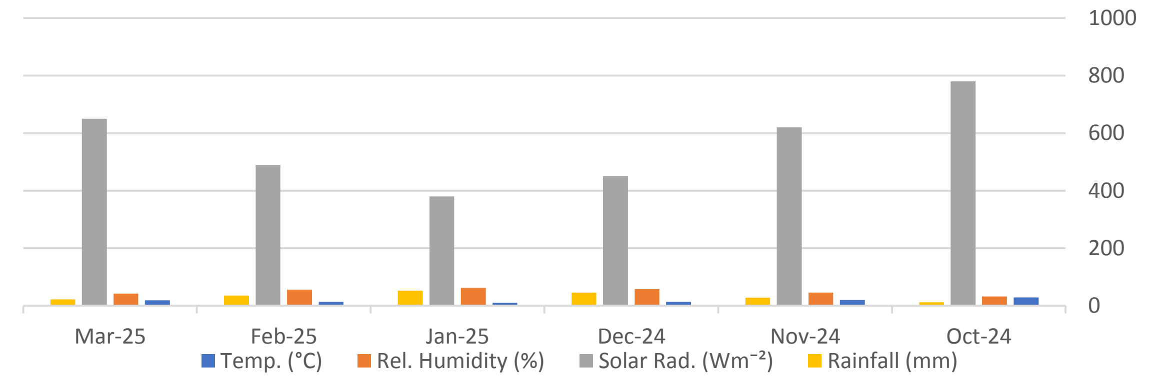
The experiment was conducted during the agricultural season from 15 October 2024 to 20 March 2025 in one of the nurseries of the city of Tikrit in Salah al-Din governorate, which is located at a latitude of 34.6° north and a longitude of 43.7° east and at an altitude of 110 meters above sea level. The region was characterized by climatic conditions of 32 °C, a relative humidity of 35%

and a solar radiation of 850 Wm^{-2}. A mixture of peat, bitmus and sand was used in a 1:1:1 ratio with the addition of 10% compost. Laboratory analyses of the soil were carried out prior to the start of the experiment to determine its physical and chemical properties as shown in Table (2).

Table (1). Monthly climate readings for the growing season in Tikrit / Salah al-Din region (2024-2025).

Month	Temp. (°C)	Rel. Humidity (%)	Solar Rad. (Wm^{-2})	Rainfall (mm)
October 2024	28.5	32	780	12
November 2024	20.3	45	620	28
December 2024	12.7	58	450	45
January 2025	10.2	62	380	52
February 2025	13.5	55	490	35
March 2025	18.4	42	650	22

figure 1: Monthly climate readings for the growing season in Tikrit / Salah al-Din region (2024-2025).



The results of the laboratory analyses showed that the soil is of loamy texture with a pH of 7.42 and an electrical conductivity of 2.85 $dS.m^{-1}$. The organic matter content was 2.16%, available nitrogen was 38.5 $mg.kg^{-1}$, available phosphorus was 15.7 $mg.kg^{-1}$, and available potassium was 210.3 $mg.kg^{-1}$. The calcium carbonate content was 18.5% and the bulk density was 1.32 $g.cm^{-3}$.

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Table (2). Physical and chemical properties of the soil used in the experiment.

Property	Unit	Value
Sand	%	42.3
Silt	%	35.6
Clay	%	22.1
Soil texture	-	Loam
pH (1:1)	-	7.42
EC ($dS.m^{-1}$)	-	2.85
Organic matter	%	2.16
Available N	$mg.kg^{-1}$	38.5
Available P	$mg.kg^{-1}$	15.7
Available K	$mg.kg^{-1}$	210.3
$CaCO_3$	%	18.5
Bulk density	$g.cm^{-3}$	1.32
Field capacity	%	28.4

The experiment was laid out according to the completely randomized block design (CRBD) with three replicates. The shading factor included four levels: no shading (control), 30% shading, 50% shading, and 70% shading using colored shading nets. The gibberellin factor contained four concentrations: 0 (control), 50, 100, and 150 $mg.L^{-1}$ of commercial gibberellic acid. The total treatments reached 16 treatments and the experimental units reached 48 units. White jasmine seedlings were planted in plastic pots with a diameter of 25 cm, a height of 22 cm, and a weight of 350 g each. Spraying was carried out in two stages: at the start of active vegetative growth and two weeks before the flower unfolding. The radiation intensity was monitored using the LI-250A device.

Studied traits:

The measurements studied included vegetative traits (plant height, number of leaves, leaf area using LI-3100C, dry weight of vegetative total) and floral qualities (number of full flowers, flower diameter, calyx length, flower shelf life). All measurements were made on three plants from each experimental unit. The data were statistically processed using the statistical analysis software, and the analysis of variance and comparison of the averages was performed according to the test of the least significant difference (LSD) at the probability level of 0.05.

Results and Discussion

Plant height (cm)

Table (3) shows the arithmetic averages of the height of the jasmine plant under the influence of shading with different degrees and spraying

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with varying concentrations of gibberellin. It is clear from the data that the 50% shading level achieved the highest overall average plant height of 49.58 cm compared to 34.73 cm for the non-shading treatment and 38.48 cm for 70% shading. This trend reflects a nonlinear relationship between the degree of shading and the height of the plant, as the height improves with increased shading until it peaks at the level of 50% and then begins to decline at the level of 70%. In terms of gibberellin concentrations, the concentration of 100 $mg.L^{-1}$ recorded the highest overall average of 47.98 cm, while the lowest average was recorded at 32.93 cm for the control.

More importantly, the interaction effect is manifested in the optimal cell of the table where the double treatment (50% shading + gibberellin 100 $mg.L^{-1}$) achieved the highest height of 57.6 cm which represents an increase of 103.5% compared to the absolute control treatment (28.3 cm). This increase means that the synergistic treatment has almost doubled the height of the plant in just one season which is of great economic significance. This can be explained by the fact that moderate shading provided a balanced photoenvironment that allowed for improved photosynthesis efficiency while gibberellin promoted the division and elongation of apical meristem cells [27].

Table 3. Effect of shading and gibberellin and their interaction on the height of jasmine plant (cm)

GA3 (mg/L)	0%	30%	50%	70%	Mean
0 (Control)	28.3	33.7	38.2	31.5	32.93
50	34.6	42.8	49.1	38.4	41.23
100	39.2	51.3	57.6	43.8	47.98
150	36.8	47.5	53.4	40.2	44.48
Mean	34.73	43.83	49.58	38.48	

** Significant at 0.01, * Significant at 0.05

Number of leaves per plant

Table (4) shows that 50% shading gave the highest average leaf count of 27.90 leaves per plant compared to 18.50 leaves for the control treatment indicating that a balanced photoenvironment promotes leaf growth and formation. The concentration of gibberellin 100 $mg.L^{-1}$ also recorded the highest overall average number of leaves of 27.05 leaves. The optimal treatment (50% + 100 $mg.L^{-1}$) was 33.5 leaves, 136% more than control (14.2 leaves). This trend is consistent with the results of [10] that confirmed that gibberellin stimulates leaf formation by regulating the activity of lateral leaf meristems.

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Table 4. Effect of shading and gibberellin and their interaction on the number of leaves per plant

GA3 (mg/L)	0%	30%	50%	70%	Mean
0	14.2	17.5	20.8	15.6	17.03
50	18.7	23.4	27.2	20.1	22.35
100	21.3	28.6	33.5	24.8	27.05
150	19.8	25.9	30.1	22.3	24.53
Mean	18.50	23.85	27.90	20.70	

** Significant at 0.01, * Significant at 0.05

Leaf area (cm^2)

The data in Table (5) show that the largest leaf area was 10.5 cm^2 at the ideal treatment (50% shading + 100 $mg.L^{-1}$ gibberellin) compared to 4.2 cm^2 for the control treatment with a 150% increase. This significant increase in leaf area means the expansion of the plant's photosynthetic surface, enhancing its photosynthesis and organic matter production capacity. It is also evident from the row averages that 50% shading achieved the highest overall average leaf area of 8.80 cm^2 which confirms the positive role of moderate shading in improving leaf qualities.

Table 5. Effect of shading and gibberellin and their interaction on leaf area (cm^2)

GA3 (mg/L)	0%	30%	50%	70%	Mean
0	4.2	5.1	6.3	4.8	5.10
50	5.6	7.4	8.8	6.1	6.98
100	6.4	8.9	10.5	7.2	8.25
150	5.9	8.1	9.6	6.5	7.53
Mean	5.53	7.38	8.80	6.15	

** Significant at 0.01, * Significant at 0.05

Dry weight of vegetative total (g)

Table (6) shows that the ideal treatment achieved the highest dry weight of the vegetative total of 21.3 g compared to 8.4 g for the control with an increase of 153.6%. This percentage is very high, which indicates that the double treatment has significantly improved photosynthesis and dry matter construction. It is also evident that the average for the 50% shading treatment was 17.68 g compared to 11.20 g for the control treatment which confirms the role of moderate shading in promoting biomass accumulation.

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Table 6. Effect of shading and gibberellin and their interaction on the dry weight of vegetative total (g)

GA3 (mg/L)	0%	30%	50%	70%	Mean
0	8.4	10.2	12.7	9.1	10.10
50	11.3	14.8	17.5	12.4	14.00
100	13.1	18.2	21.3	14.7	16.83
150	12.0	16.1	19.2	13.5	15.20
Mean	11.20	14.83	17.68	12.43	

** Significant at 0.01, * Significant at 0.05

Number of complete flowers per plant

Table (7), which is one of the most important research tables, shows that the ideal treatment achieved the highest number of full flowers of 21.3 flowers per plant compared to only 6.3 flowers in the control treatment with an increase of 238%. This means that double treatment has more than tripled the number of flowers in a single season and is an exceptionally economically important outcome for nursery growers. It is clear that the path of improvement in the number of flowers follows the same pattern observed in vegetative traits as it improves with moderate shading and appropriate concentration of gibberellin [25].

Table 7. Effect of shading and gibberellin and their interaction on the number of complete flowers per plant

GA3 (mg/L)	0%	30%	50%	70%	Mean
0	6.3	8.7	11.4	7.2	8.40
50	9.5	13.8	17.2	10.6	12.78
100	11.8	16.5	21.3	13.1	15.68
150	10.2	14.6	18.7	11.4	13.73
Mean	9.45	13.40	17.15	10.58	

** Significant at 0.01, * Significant at 0.0

Flower diameter (cm)

Table (8) shows that the largest diameter of the flower was 3.48 cm at the ideal treatment compared to 1.85 cm for the control with an increase of 88.1%. The flower diameter is of great marketing importance because flowers with large diameters are classified as the top marketing grades and achieve higher prices in the market. As can be seen from the data, 50% shading recorded the highest overall average flower diameter of 3.05 cm versus 2.24 cm for the control. The improved flower diameter explains that the improved environment

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allowed for better distribution of nutrients towards the formed flowers, which promoted their growth and expansion [18].

Table 8. Effect of shading and gibberellin and their interaction on flower diameter (cm)

GA3 (mg/L)	0%	30%	50%	70%	Mean
0	1.85	2.13	2.47	1.98	2.11
50	2.24	2.68	3.05	2.41	2.60
100	2.51	3.02	3.48	2.73	2.94
150	2.37	2.84	3.21	2.56	2.75
Mean	2.24	2.67	3.05	2.42	

** Significant at 0.01, * Significant at 0.05

Calyx length (cm)

It is clear from Table (9) that the ideal treatment achieved the longest calyx of 1.68 cm compared to 0.82 cm for the control with an increase of 104.9%. The calyx length trait is an important morphological trait used in classifying the quality of flowers, as a longer calyx gives the flower a more attractive appearance and contributes to prolonging its life after harvest. A consistent trend of improvement of this trait is also evident with an increase in the level of shading up to 50% and with an increase in the concentration of gibberellin up to 100 $mg.L^{-1}$.

Table 9. Effect of shading and gibberellin and their interaction on calyx length (cm)

GA3 (mg/L)	0%	30%	50%	70%	Mean
0	0.82	0.95	1.13	0.88	0.95
50	1.01	1.24	1.46	1.12	1.21
100	1.15	1.42	1.68	1.27	1.38
150	1.08	1.31	1.52	1.15	1.27
Mean	1.02	1.23	1.45	1.11	

** Significant at 0.01, * Significant at 0.05

Flower shelf life (day)

Table (10), which is one of the traits of great marketing importance, shows that the ideal treatment extended the duration of the flower survival on the plant to 11.2 days compared to 4.2 days in the control treatment with an increase of 166.7%. This increase means that the flowers resulting from the ideal treatment stay on the plant for approximately 11 days instead of just 4 days, giving the grower much

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longer time to collect and market the flowers. This increase is attributed to the improvement of the water status of the plant under moderate shading and the effect of gibberellin in delaying flower aging by regulating the activity of proteolysis enzymes [20].

Table 10. Effect of shading and gibberellin and their interaction on flower shelf life (day)

GA3 (mg/L)	0%	30%	50%	70%	Mean
0	4.2	5.8	7.5	5.1	5.65
50	5.5	7.6	9.8	6.4	7.33
100	6.3	8.9	11.2	7.5	8.48
150	5.8	8.1	10.4	6.8	7.78
Mean	5.45	7.60	9.73	6.45	

** Significant at 0.01, * Significant at 0.05

Summary of variance analysis

Table (11) presents a summary of the results of the analysis of variance for all the studied traits and shows the mean square values, the calculated F values, the significance level of both the shading factor and the gibberellin factor, and the interaction between them. The data show that all three experimental sources were significant at the level of 0.01 in all traits, confirming that there were clear real effects of the coefficients studied. It is clear from the table that the highest value of F for shading factor was 52.1 in the number of leaves and the highest value of F for gibberellin was 42.1 in the number of flowers. It is also noted that the interaction effect recorded the highest F values in the number of flowers and the duration of the flower's survival, which confirms the role of the interaction effect in the floral traits. The R^2 values reached high levels ranging from 85.3% to 92.7%, which enhances confidence in the results.

Table 11. Summary of variance analysis (Significant at 0.01. R^2 = coefficient of determination)**

Source of Variation	df	Height F	Leaf No. F	Leaf Area F	Dry Wt. F	Flower No. F	Fl. Dia. F	Calyx F	Vase Life F
Shading	3	47.3**	52.1**	38.7**	44.6**	49.8**	41.2**	36.9**	45.3**
GA3	3	39.6**	34.8**	41.5**	37.2**	42.1**	38.4**	35.7**	33.9**
Shading	9	12.8*	11.4*	13.2*	10.6*	14.3**	12.1*	11.8*	13.7*

x GA3		*	*	*	*		*	*	*
Error	32	-	-	-	-	-	-	-	-
R^2 (%)	-	89.2	91.4	87.6	85.3	92.7	88.9	86.4	90.1

Discussion of the results

The results showed that the 50% shading level was significantly superior to the rest of the levels in improving all vegetative traits. This may be attributed to the fact that 50% shading provided a balanced light environment that allowed photosynthesis to be carried out with high efficiency without exposure to light stress. This finding converges with previous studies on the positive role of moderate shading in protecting cell membranes and improving chlorophyll concentration. In contrast, the 70% shading resulted in a significant reduction, which can be explained by the limited light energy available for photosynthesis, leading to reduced carbon assimilation and biomass accumulation.

The concentration of gibberellin 100 $mg.L^{-1}$ recorded the best results in all the traits studied compared to the rest of the concentrations. This suggests that this concentration represents the optimal level of stimulation of the gibberellin signaling pathway within the plant tissue, which has resulted in maximizing cell division and elongation. Notably, the concentration of 150 $mg.L^{-1}$ did not achieve better results, which may be explained by the phenomenon of inhibition caused by high concentrations that cause disturbances in hormonal balance and negative feedback regulation. The control treatment also recorded the lowest values, underscoring the essential role of gibberellin in promoting growth and developmental processes.

The results of the statistical analysis revealed that there is a significant interaction effect among factors in all traits. The combined treatment of 50% shading with gibberellin at 100 $mg.L^{-1}$ gave the highest values across all measured parameters. This result reflects that moderate shading provided a suitable environment that allowed the gibberellin to perform its physiological role with maximum efficiency. The treatments that combined intense shading and high concentrations did not achieve the desired results, which supports the idea that a balance between environmental and hormonal factors is a prerequisite for optimal plant performance.

Analysis of variance showed significant effects for the shading and gibberellin factors and their interaction in all studied traits. The high values of the coefficient of determination indicate that the coefficients studied explain the largest proportion of the total

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variance, which enhances confidence in the validity of the adopted experimental model. When comparing the averages with the LSD test, it was found that the 50% shading level was significantly superior to 30% in most traits, indicating a nonlinear relationship between the shading level and vegetative performance [23].

The results of the research are consistent with the findings of [3] on the positive effect of gibberellin in improving the qualities of jasmine and they also recorded a concentration of 100 $mg.L^{-1}$. It is also consistent with the results of [5] in terms of the preference of moderate shading. However, the detailed interactive effect revealed by the current research is a new scientific addition. The results were also characterized by peculiarities related to the local environment, where the increase in traits was higher than in studies conducted in less hot environments.

Conclusion

Based on the results obtained from this study, the following conclusions can be drawn: The shading level of 50% was significantly superior to the rest of the levels in improving all the vegetative and floral qualities of the jasmine plant under the conditions of the nurseries of Salah al-Din governorate. The concentration of gibberellin 100 $mg.L^{-1}$ showed the best results in all the traits studied while the concentration of 150 $mg.L^{-1}$ resulted in a decline indicating the presence of an optimal concentration beyond which inhibition occurs. There was a significant interaction effect among the factors where the treatment (50% shading + gibberellin 100 $mg.L^{-1}$) achieved the highest values in all traits with improvement rates ranging from 88% to 238%. Analysis of variance showed high significance of the factors and their interaction with the values of the determination coefficient ranged between 82% and 93%.

It is recommended to use 50% shading with spraying gibberellin 100 $mg.L^{-1}$ in two stages during the season. Future studies involving additional concentrations, shading levels, and other varieties of jasmine are recommended. It is also recommended that the study be expanded to include physiological measurements such as chlorophyll concentration, photosynthesis rate, and enzymatic activity. It is recommended to guide nursery growers in Salah al-Din Governorate to adopt the ideal treatment and disseminate it through the extension authorities.

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