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RESEARCH ARTICLE
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Effect of Shading, Organic Fertilizer (vermicompost), and Chelated Iron on the Vegetative Growth Characteristics of *Gardenia jasmoida* .

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ABSTRACT

The experiment was conducted in a private nursery (Mohammed Nursery) located on Erbil Road in Kirkuk, situated at 44.38°E longitude and 35.58°N latitude. The experiment lasted five months from 01/04/2022 to 01/10/2022 to study the effects of shading with two levels: 0% (under direct sunlight) and 75% (under saran cover), as well as the effect of organic fertilizer (vermicompost) at two levels: 0% and 25%, where the fertilizer was added and mixed with loamy soil and add chelated iron at three different levels sequentially to the soil every 15 days (0 - 0.1- 0.2) g.l-1. The experiment was conducted using a completely randomized block design. The plants were randomly arranged on the experimental units with three replicates. Duncan's multiple range test was used to compare the means at a probability level of 0.05%. The results indicated that the 75% shading had a significant effect on some characteristics, such as plant height, dry leaf weight, and leaf area, which reached (82.27 cm), (12.14 g), and (3086.10 cm^2) respectively. On the other hand, plants grown under direct sunlight showed a significant increase only in stem diameter (10.69 mm).

Regarding the effect of organic fertilization, a significant increase was observed with the use of 25% vermicompost on the following characteristics: plant height (73.55 cm), dry weight (12.63 g), and chlorophyll content in leaves (29.24 CCI).

It was also found that the use of chelated iron significantly affected most characteristics, with the concentration of 0.2 $g.l^{-1}$ resulting in the highest significant increase in plant height (75.00 cm), main stem diameter (10.37 mm), dry weight (15.35 g), and chlorophyll content in leaves (29.10 CCI).

***Keywords*:** Shading, Compost, Worm Fertilizer, Chelated Iron, Vegetative Growth.

INTRODUCTION

The gardenia plant belongs to the Rubiaceae family and thrives in acidic environments. China and Japan are the original habitats for these plants [1]. The gardenia is a tropical, flowering, evergreen shrub known for its fragrant blossoms. It features shiny green leaves and snowy, aromatic flowers that are either solitary or clustered. These flowers have a lifespan of about three days, transitioning from white to yellow. The fruit is an orange, oval-shaped capsule containing seeds [2] and [3].

Recently, the world has experienced increased temperatures, more light, and lower humidity, negatively impacting plant growth. To counter this, shading is used to reduce light intensity and lower temperatures [4]. Organic fertilizers are crucial for providing essential macro and micronutrients, and they improve the physical, chemical, and biological properties of the soil. Vermicompost is highly porous, well-aerated, has good drainage, water retention capacity, and is odorless, unlike animal manure.

Supplying plants with nutrients like iron is vital for various biological processes, either directly as a structural component or by activating enzymatic processes within the plant. Iron is essential for oxidation-reduction processes and chlorophyll synthesis. It is preferable to add iron to the soil either by foliar application or as a soil drench in chelated form [5] Due to the limited research, the experiment or study has been conducted.

Materials and Methods:

The experiment was conducted at Mohammed's nursery on the road to Erbil during the 2022 agricultural season. The study was performed on gardenia plants propagated by cuttings and grafted onto rootstocks. One-year-old uniform gardenia seedlings were obtained at the start of the experiment. Seventy-two gardenia plants were prepared and planted in silty loam soil in 15 cm diameter plastic pots, ensuring all weeds were removed, and maintenance operations were performed as needed [6].

The study investigated the effects of three factors:

1. Shading at two levels: 0% (direct sunlight) and 75% (covered with a green net).
2. Organic fertilizer at two levels: 0% and 25%, added to the soil when repotting the plants.

3. Chelated iron at three levels: 0, 0.1, and 0.2 g.l $^{-1}$, dissolved in water and applied to the plants early in the morning every 15 days.

Temperature and relative humidity were measured using a lux meter. The experiment followed a randomized complete block design with each experimental unit containing two gardenia seedlings and replicated twice. The treatment combinations included two shading levels (0-75%), two levels of organic fertilizer (0-25%), and three levels of chelated iron (0-0.1-0.2 g.l^{-1}). Means were compared using the Least Significant Difference (LSD) test at a 0.05 probability level [7] .

At the end of the experiment on October 1, 2022, the following parameters were measured:

1. Plant Height: Measured from the soil surface to the highest point of the plant using a measuring tape.
2. Main Branch Diameter: Measured 1 cm above the grafting point using a digital vernier caliper.
3. Leaf Area: Calculated by multiplying the area of a single leaf by the number of leaves per plant.
4. Dry Weight of Leaves: Leaves were collected in a perforated envelope, placed in an electric oven at 70°C for 72 hours, and then weighed using a sensitive balance to determine the average dry weight per plant [8].
5. Total Chlorophyll Content (CCI): The total chlorophyll content was measured using an Opti-Sciences device. Ten fully grown leaves per plant were read, and the average content was calculated.

Results and Discussion:

1. Plant Height (cm):

From Table (1), it is observed that the 75% shading treatment outperformed in terms of plant height, reaching 82.27 cm². The increase in plant height is attributed to the fact that plants growing in the shade are deprived of near-red light, while far-red light penetrates their tissues, particularly the internodes. Exposure to far-red light increases gibberellin, leading to taller plants due to severe shading. This is because phytochrome, which participates in light synthesis, exists as Pr in light and as Pfr in darkness, influencing growth in dark environments by elongating stems to reach light for photosynthesis [9]. When plants are watered with chelated iron at a concentration of 0.2 g/L, the increase in height attributes to the role of iron in building essential polymers used in cell division and chlorophyll formation, which are crucial for plant growth [10]. Organic fertilizer application also showed a significant increase in plant height, reaching 73.55 cm², as it promotes cell proliferation and elongation, potentially acting as an enzyme in metabolic processes that enhance vegetative growth indicators, particularly height [11].

2. Stem Diameter (mm):

Table (2) shows that 0% shading (under direct sunlight) significantly outperformed 75% shading (green net). This agrees with the findings of [12] that increased direct sunlight exposure enhances stem diameter due to carbohydrate accumulation. Light stimulates cytokinin production, which is transported to the vegetative parts, increasing stem diameter [13]. Chelated iron application to plants increases the synthesis of nutrients, leading to carbohydrate accumulation and thickening of the stem diameter [14]

3. Leaf Area (cm²):

Table (3) indicates that 75% shading (plants covered with a green net) significantly increased leaf area to 3086.10 cm². The increase in leaf area results from reduced light intensity reaching the plant, enlarging leaf cells and tissue, enhancing the plant's ability to capture more light for photosynthesis to compensate for the deficit [15]. Shading up to 60% leads to auxin redistribution to the leaf, increasing its area due to auxin accumulation in leaf tissues from reduced shading. Leaf area decreases in hot, dry climates compared to warm ones due to smaller cell size and fewer cells, reducing dry weight. Plants grown under high shading have chloroplasts near the upper cell surface and well-formed grana for maximum light capture [16]. Fertilization with 0.2 g/L chelated iron significantly increased leaf area to 2721.1 cm² due to iron's crucial role in photosynthesis and chlorophyll production, enhancing vegetative growth and leaf area [17]. Organic fertilizer application also significantly increased leaf area to 2543.4 cm², attributed to the essential nutrients in organic fertilizers, such as organic and amino acids, which enhance plant absorption and activity [18][19]

4. Leaf Dry Matter:

Table (4) shows that leaf dry matter increased with shading (12.14 g), attributed to lower leaf temperature and reduced respiration rates, leading to the accumulation of photosynthesis products in vegetative parts (leaves, branches, and roots) [20]. Organic fertilizer resulted in 12.63 g dry matter due to Vermicompost's content of growth-promoting hormones that induce cell division and activate vital processes, increasing dry weight and leaf number, along with its high nutrient content released during decomposition, enhancing photosynthesis and carbohydrate production [21] and [22]. Fertilizer treatments improved vegetative traits due to providing an acidic medium that facilitates ion binding and soil protection, enhancing cell membrane permeability, nutrient absorption, biological activity, and respiration, thus boosting photosynthesis (22). Chelated iron at 0.2 g/L significantly increased leaf dry matter to 15.35 g, as iron is involved in building essential polymers for cell division and chlorophyll formation, enhancing plant growth [24] and [25]. Additionally, iron activates oxidation-reduction enzymes in the respiratory chain, aiding in chlorophyll synthesis and chloroplast storage as Phytoferritin, leading to vegetative growth [26].

5. Leaf Chlorophyll Content (CCI):

Table (5) shows no significant differences between different shading levels. However, fertilization with 0.2 g/L chelated iron significantly increased chlorophyll content to 29.10 CCI, as iron plays a fundamental role in photosynthesis, DNA and RNA synthesis necessary for cell division, and chlorophyll molecule formation essential for photosynthesis and plant growth

[27]. Organic fertilizer significantly increased chlorophyll content to 29.24 CCI compared to the control, attributed to its rich nutrient content vital for plant biochemical activities, growth, and development, contributing to chlorophyll formation [28

table (1) Effect of Shading, Organic Fertilizer (Vermicompost), and Chelated Iron on the Plant Height (cm) of *Gardenia jasminoides'* Vegetative Growth

Shade (%)	Organic Fertilizer (%)	Chelated Iron (g/L) 0	0.1	0.2	Shading Rate
0	0	49.83 e	49.70 c	56.16 e	57.00 b
	25	56.83 e	59.50 cd	70.00 cd	
75	0	76.16 bc	81.83 abc	82.50 ab	82.27 a
	25	82.25 abc	77.83 bc	93.16 a	
Iron Chelated Rate		66.70 b	67.21 b	75.00 a	

Organic Fertilizer Rate	0		25
	65.55 b		73.55 a

Bilateral Shading Interaction (%) + Organic Fertilizer (%)	0	0	25
		51.90 c	62.11 b
	75	79.55 a	85.00 a

Bilateral Shading Interaction (%) + Iron (g/L)	0	0	0.1	0.2
		53.33 c	54.60 c	63.08 b
	75	80.08 a	79.83 a	86.91 a

Bivariate interaction of organic fertilizer (%) + iron (g/L)	0	0	0.1	0.2
		63.00 b	65.76 b	68.41 b
	25	70.41 b	68.66 b	81.58 a

Different letters within the same column indicate significant differences ($p < 0.05$) among treatments

Table (2): Effect of shading, organic fertilizer (vermicompost), and chalted iron on the main trait of stem diameter (mm) in the vegetative growth of *Gardenia Jasminoides.*

Shade (%)	Organic Fertilizer (%)	Chelated Iron (g/L) 0	0.1	0.2	Shading Rate

0	0	7.88 e	10.75 abcd	11.70 ab	10.69 a
	25	10.03 bcde	10.84 abc	12.95 a	
75	0	8.16 ed	8.91 cde	8.27 cde	8.68 b
	25	9.31 bcde	8.82 cde	8.27 cde	
Iron Chelated Rate		8.85 b	9.83 ab	10.37 a	

Organic Fertilizer Rate	0 9.33 a	25 10.04 a	

		0	25
Bilateral Shading Interaction (%) + Organic Fertilizer (%)	0	10.11 ab	11.27 a
	75	8.55 c	8.81 bc

		0	0.1	0.2
Bilateral Shading Interaction (%) + Iron (g/L)	0	8.96 b	10.79 a	12.32 a
	75	8.75 b	8.86 b	8.43 b

		0	0.1	0.2
Bivariate interaction of organic fertilizer (%) + iron (g/L)	0	8.02 b	9.83 a	10.14 a
	25	9.68 a	9.83 a	10.61 a

Different letters within the same column indicate significant differences ($p < 0.05$) among treatments

Table (3): Effect of shading, organic fertilizer (vermicompost), and chalted iron on the

Shade (%)	Organic Fertilizer (%)	Chelated Iron (g/L) 0	0.1	0.2	Shading Rate
0	0	1440.3 e	1932.7 cde	1953.5 cde	1597.5 b
	25	1292.3 e	1295.5 e	1671.0 ed	
75	0	1691.5 ed	2690.3 bcd	2913.3 bc	3086.1 a
	25	3439.3 ab	3479.4 ab	4127.3 a	
Iron Chelated Rate		1954.8 b	2349.5 ab	2721.1 a	

	0	25

Organic Fertilizer Rate		2140.2 b	2543.4 a	
Bilateral Shading Interaction (%) + Organic Fertilizer (%)		0	25	
	0	1775.5 c	2504.3 b	
	75	1419.6 c	3667.3 a	
Bilateral Shading Interaction (%) + Iron (g/L)		0	0.1	0.2
	0	1366.3 c	1614.1 c	1812.2 c
	75	2543.3 b	3084.9 ab	3630.1 a
Bivariate interaction of organic fertilizer (%) + iron (g/L)		0	0.1	0.2
	0	1565.9 b	2311.6 a	2543.2 a
	25	2343.7	2387.4 a	2899.1 ab

leaf, and chalted iron on the leaf area (cm²) in the vegetative growth of *Gardenia Jasminoides*Different letters within the same column indicate significant differences ($p < 0.05$) among treatments.

Table (4): Effect of shading, organic fertilizer (vermicompost), and wrought iron on leaf dry weight (g) in the vegetative growth of *Gardenia Jasminoides*.

Shade (%)	Organic Fertilizer (%)	Chelated Iron (g/L) 0	0.1	0.2	Shading Rate
0	0	8.30 cde	7.23 de	12.54 bcd	10.69 a
	25	7.68 cde	7.27 de	12.84 bc	
75	0	3.99 e	6.23 e	14.35 b	8.68 b
	25	12.28 bcd	15.30 b	21.41 a	
Iron Chelated Rate		7.81 b	9.01 b	15.35 a	
Organic Fertilizer Rate		0 8.82 b		25 12.63 a	
Bilateral Shading Interaction (%) + Organic Fertilizer (%)		0		25	
	0	9.35 b		9.26 b	
	75	8.28 b		16.00 a	
		0	0.1	0.2	
	0	7.99 c	7.25 c	12.69 b	

Bilateral Shading Interaction (%) + Iron (g/L)	75	7.64 c	10.77 bc	18.02 a
		0	0.1	0.2
Bivariate interaction of organic fertilizer (%) + iron (g/L)	0	6.14 d	6.73 d	13.58 b
	25	9.49 cd	11.28 bc	17.13 a

Different letters within the same column indicate significant differences ($p < 0.05$) among treatments

Table (5): Effect of shading, organic fertilizer (vermicompost), and chalted iron on leaf chlorophyll content in Gardenia Jasminoides

Shade(%)	Organic Fertilizer (%)	Chelated Iron (g/L)			Shading Rate
		0	0.1	0.2	
0	0	5.04 g	13.04 f	24.48 de	21.60 a
	25	26.80 cd	25.90 cd	34.33 ab	
75	0	6.14 g	13.06 f	26.05 cd	21.60 a
	25	20.71 e	29.87 bc	35.58 a	
Iron Chelated Rate		15.24 c	20.46 b	29.10 a	
		0		25	
Organic Fertilizer Rate		29.24 a		13.96 b	
		0		25	
Bilateral Shading Interaction (%) + Organic Fertilizer (%)	0	14.18 b		29.01 a	
	75	13.73 b		29.48 a	
		0	0.1	0.2	
Bilateral Shading Interaction (%) + Iron (g/L)	0	15.92 c	19.47 b	29.40 a	
	75	14.56 c	21.46 b	28.79 a	
		0	0.1	0.2	
Bivariate interaction of organic fertilizer (%) + iron (g/L)	0	5.59 e	13.05 d	23.24 c	
	25	24.89 c	27.88 b	34.96 a	

Different letters within the same column indicate significant differences ($p < 0.05$) among treatments

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تاثير التظليل والسماد العضوي والحديد المخلبي في صفات النمو الخضري لنبات الكاردينيا *Gardenia jasmoida*.

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الخلاصة

تم اجراء التجربة في مشتل خاص(مشتل محمد) الكائن على طريق اربيل في كركوك . الواقعة على خط الطول 44.38 شرقا و خط العرض 35.58 شمالا . دامت فترة التجربة خمسة اشهر من تاريخ 2022/04/01 الى تاريخ 2022/10/01 لدراسة تاثير تظليل بمستوين تظليل 0% (تحت اشعة الشمس المباشرة) و مستوى 75% (تحت غطاء الساران) و ايضا دراسة التسميد بالسماد العضوي (دود) *Vermicompost* بمستوين بنسبة 0% و 25% حيث تمت اضافة السماد و خلطها مع التربة المزيجية ، و اضافة الحديد المخلبي بمستويات مختلفة الى التربة ريا (0 – 0.1 – 0.2) غم.لتر$^{-1}$. و تم اجراء التجربة باستخدام تصميم قطاعات العشوائية الكاملة . رتبت النباتات عشوائيا على الوحدات تجربة بواقع ثلاث مكررات . تم اعتماد اختبار دنكن متعدد الحدود بمقارنة المتوسطات عند مستوى احتمالية 0.05% اوضحت نتائج الجدول ان تاثير التظليل : بنسبة 75% كان له تفوقا معنويا في بعض الصفات التالية :ارتفاع النبات ، و الوزن الجاف للاوراق ، مساحة الورقية بلغت (82.27 *cm* ،*(12.14 g*)، (3086.10) سم2 على التوالي بينما اعطت النباتات المزروعة في الشمس تفوقا فقط في قطر الساق (10.69) ملم. اما تاثير التسميد العضوي فقد ثبتت تاثيرها بزيادة معنوية عند استخدام السماد العضوي بنسبة 25% على الصفات الاتية : ارتفاع النبات و الجاف و محتوى الاوراق من الكلوروفيل (73.55) سم (و (12.63) غم(29.24) *CCI* ، و اتضح عند استعمال الحديد المخلبي: كان له تاثيرا معنويا في معظم الصفات حيث عند استخدام تركيز 0.2 غم.لتر$^{-1}$ اعطى اعلى تفوق معنوي عند صفات الاتية : ارتفاع النبات و قطر الساق الرئيسي و الوزن الجاف ومحتوى الاوراق من كلوروفيل (75.00) سم (10.37) ملم (15.35) غم (29.10) *CCI* على التوالي .

الكلمات المفتاحية : التظليل ، السماد العضوي ، السماد الدودي ، حديد المخلبي ، النمو الخضري ، كاردينيا.