Role of Sowing date and Gibberellic Acid Spray on Growth and Quality Traits of Faba Bean

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Abstract

A field experiment was carried out to study the effect of growth regulator foliar spray and thermal accumulation during the winter season of 2024-2025 on a Spanish variety of Faba bean (*Vicia faba* L.) 'Luz de Oton' Cv. The experiment was carried out on silty clay soil at Al-Mahnawiyya Extension Farm belonging to Babylon Training and Extension Center (32.61°N, 44.30°E). The study was conducted using Randomized Complete Block Design (RCBD) with a split plot arrangement and three replications. The purpose of the study was to examine the effect of thermal accumulation and gibberellic acid (GA_3) spray on Faba bean growth and quality. The treatments in the main plot were four sowing dates: 1 October, 15 October, 1 November and 15 November (D1, D2, D3 and D4, respectively). Subplots were assigned six concentrations of gibberellic acid: 0, 50, 100, 150, 200, and 250 mg L^{-1}, designated as G0, G1, G2, G3, G4, and G5, respectively. The vegetative growth and qualitative traits were measured at physiological maturity. In the branching stage foliar application of gibberellic acid (GA3) was applied to the vegetative parts according to prescribed treatments. The control treatment was sprayed with distilled water only. The results indicated that the highest average of plant height, branch numbers and chlorophyll content (73.11 cm),(8.83 branch plant -1), and (47.09 SPAD) were recorded at the second planting date (D2). On the other hand, the first planting date (D1) has the highest averages of protein percentage, total carbohydrate and thermal accumulation (GDD)(32.278%, 49.078%, 1089.10∘C·d). Moreover, the highest average of most of the studied traits were recorded when spraying plants with gibberellic acid at 250 mg L^{-1} (G5). Planting dates by gibberellic acid concentrations interaction significantly affected some traits; In this respect, interaction treatment D1G5 led to the highest protein and carbohydrate percentages (37.829%, 52.606%). But the interaction was not significant for other traits.

Keywords: Faba bean, Thermal accumulation, Gibberellic acid.

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Introduction

Faba bean (*Vicia faba* L.) is a primary winter legume that belongs to the Fabaceae family. It represents an important source of food in many countries, especially those with limited income. This crop is versatile, grown as a green vegetable for the pods or as dried seeds used in human nutrition and animal feed. It is distinguished by its high nutritional value, providing a high protein content (25–37%) and carbohydrates (51–68%) together with essential mineral nutrients [34, 20]. In addition, it has the ability to form symbiotic relationships with Rhizobium bacteria, which leads to biological nitrogen fixation in the soil, which significantly reduces the dependence on artificial fertilizers [11, 10]. The importance of studying planting dates under global climate change, including Iraq, has intensified due to global warming and recent increases in terrestrial temperatures. These changes require re-evaluation of optimal sowing dates. Variation in environmental factors between dates significantly affects the timing and duration of the vegetative and reproductive stages, which are critical requirements for crop management, seed production, crop components and seed quality [2, 9]. To reach physiological maturity, plants require growth regulators for their important role in enhancing biological activity. Gibberellic acid (GA_3), a plant hormone isolated from the fungus Gibberella fujikuroi, promotes vegetative growth by stimulating internode elongation, increasing the number of pods, flowers and leaves. It also induces early flowering and pod development, breaks seed dormancy, accelerates ripening and mediates various physiological processes [31]. In addition, it plays an important role in plant mechanisms that increase stress tolerance in crops [8]. Understanding growing degree days (GDD) is critical to determining growing season, maturity dates, and harvest time. GDD is used to identify thermal requirements to initiate different developmental stages, such as germination, flowering and ripening [26 , 18]. This Trait helps farmers plan irrigation, fertilizer and pest control [13]. These units are calculated based on the difference between the daily average temperature and the basal temperature, which is the minimum temperature required for growth [4]. Objectives of the study:

• To determine the optimum planting date for broad bean crops.

• To identify the best concentration of gibberellic acid to increase growth and qualitative characteristics.

• To evaluate the most effective interaction between planting dates and gibberellic acid sprays to maximize growth and quality traits.

Material and Methods

A field experiment was conducted during the 2024–2025 winter growing season to evaluate the Spanish Faba bean variety (*Vicia faba* L.) 'Luz de Oton' Cv. The study was located at the Al-Mahnawiyya Extension Farm associated with the Babylon Training

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and Extension Centre, which is located 8 km north of Babylon (latitude 32.61°N, longitude 44.30°E). The soil at the experimental site is known as silty clay. Before sowing, random soil samples were taken from the field at a depth of 0–30 cm. The samples were mixed thoroughly, air dried, crushed and passed through a 2 mm sieve to prepare a composite sample. This mixed sample was used to determine the initial physical and chemical properties of the soil, as presented in Table 1.

Table 1. Physical and chemical properties of the experimental field soil before sowing (depth 0–30 cm).

Unit	**trait**	
1.38	Bulk density Mg m^{-3}	
7.8	(pH)	
3.00	Electrical conductivity (EC)	
43.5	N	Available nutrients (mg kg^{-1})
7.3	P	
161	K	
0.58	Organic matter g kg^{-1} soil	
340	Clay	Soil separates (g kg^{-1})
607.5	silt	
51.6	loam sand	
Silty clay loam	Soil texture	

The field was prepared with two vertical plowings with a moldboard plow to a depth of 30 cm, followed by harrowing and levelling. Primary irrigation channels were established using a special channel opener. The experimental field was divided into three blocks (replicates), each block containing 24 experimental units. Each experimental unit consisted of four rows Furrow each row was 3 m long. Sowing was done on one side of the ridge, with row spacing between plants of 75 cm and row spacing of 25 cm. A buffer zone of 1 m was maintained between experimental units, and a distance of 1.5 m was left between replicates. Seed calibration was performed before sowing and the seeds were soaked in water for 24 h to increase germination. The experiment involved four different planting dates. Post-sowing cultural practices, including hand weeding and Thinning were carried out 14 days after germination to ensure one plant per plot. Irrigation and other maintenance work was carried out according to crop requirements throughout the season. In the branching stage foliar application of gibberellic acid (GA3) was applied to the vegetative parts according to prescribed treatments. The control treatment was sprayed with distilled water only.

Studied traits:

1.Plant height (cm): The average height of ten plants randomly selected from the middle rows in each experimental unit

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was measured from the soil surface to the top of the plant.

2.Number of branches (branch plant-1): The number of primary branches for the same ten randomly selected plants was recorded, and the average was calculated.

3.Chlorophyll Index (SPAD units): Total chlorophyll content in leaves was determined using a portable chlorophyll meter (model SPAD-502). Measurements of fully expanded upper leaves were taken during the flowering stage.

4.Nitrogen content (%): The percentage of nitrogen (N) in leaves was determined using the micro-Kjeldahl method, as described in [25].

5.Seed protein content (%): The protein percentage in seeds was calculated by determining the nitrogen content using a micro-Kjeldahl apparatus according to AOAC methods [1], and then multiplying the nitrogen percentage by the factor 6.25.

6.Carbohydrate content (%): Total carbohydrate was estimated using the phenol-sulfuric acid colorimetric method, which is considered to be the most reliable and effective technique according to [15].

7.Growing degree days to 100% flowering (GDD): Thermal accumulation was recorded for each experimental unit. Cumulative GDD from sowing to 100% flowering was calculated according to the formula described by [4].

Statistical Analysis

The collected data were subjected to analysis of variance (ANOVA) followed by Randomized Complete Block Design (RCBD) in a split plot arrangement. Treatment means were compared using the least significant difference (LSD) test at a probability level of 0.05. Statistical analysis was performed using GenStat software (12th edition) [5].

Results and Discussion

1. Plant Height (cm): The results presented in Table 2 indicate that both planting dates and gibberellic acid foliar application had significant effects on plant height. It was observed that planting dates significantly affected this trait, treatment D2 recorded the highest average plant height of 73.11 cm compared to treatment D4, which produced the lowest average of 62.17 cm (17.59% increase). This superiority can be attributed to favorable climatic conditions associated with the second planting date, which positively improved this growth trait. These findings are consistent with the results reported by [22] and [16]. Furthermore, the data in the same table showed that gibberellic acid spraying had a significant effect, with treatment G5 producing the tallest plants, averaging 73.67 cm, while the control (G0) averaged 59.75 cm (an increase of 23.29%). The increase in plant height is basically due to the physiological role of gibberellic acid in promoting cell division and internode elongation as well as stimulating general growth and cell expansion [30, 3]. These results agree with the findings of [12]

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and. [31] Regarding the interaction between Sowing and gibberellic acid, the results showed no significant differences for this trait, indicating that each factor acts independently.

Table (2). The role of Sowing date and spraying with gibberellic acid on growth and qualitative traits of Faba bean in the trait of plant height (cm).

Concentrations GA^3 / Sowing Dates	G0	G1	G2	G3	G4	G5	mean
D1	61.67	67.33	70.00	66.33	66.00	74.33	67.61
D2	63.67	72.67	73.00	72.67	77.67	79.00	73.11
D3	59.67	70.67	70.67	66.67	66.00	71.67	67.56
D4	54.00	60.67	64.67	60.33	63.67	69.67	62.17
mean	59.75	67.83	69.58	66.50	68.33	73.67	
L.S.D(5%)	**D (**3.444**)**		**GA_3 (**4.537**)**		**D×GA_3 (N.S)**		

2. Number of Branches (branch plant -1): The results in Table 3 indicate that both Sowing dates and gibberellic acid foliar application had significant effects on the number of branches per plant. Planting dates significantly affected this trait, with treatment D2 recording the highest number of branches, on average 8.83 branches plant-1, compared to treatment D4, which recorded the least, on average 6.33 branches plant-1 (an increase of 39.49%). This superiority can be attributed to favorable climatic conditions, which increased the overall efficiency of the plant, leading to increased cell division and expansion, and consequently an increase in the number of branches per plant. These findings agree with the results of [32] and [16]. The data in the same table also showed that spraying gibberellic acid significantly affected this trait, treatment G5 achieved the highest average of 9.50 branch plants-1 compared to the control (G0) which recorded 5.58 branch plants-1 (increase of 70.25%). The increase in branch number is due to

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the physiological role of gibberellic acid in promoting cell division and expansion as well as stimulating growth and cell expansion [30, 3]. These results agree with the findings of [32] and [31]. Regarding the interaction between planting date and gibberellic acid, it was clear from the table that there were no significant differences for this trait, indicating that the effect of each factor acted independently.

Table (3). The role of Sowing date and spraying with gibberellic acid on growth and qualitative traits of Faba bean in the trait of number of branches.

Concentrations GA^3 / Sowing Dates	G0	G1	G2	G3	G4	G5	mean
D1	5.67	7.00	7.33	8.00	9.00	9.67	7.78
D2	7.00	8.33	8.67	9.00	9.67	10.33	8.83
D3	5.33	5.67	6.00	7.00	8.00	9.33	6.89
D4	4.33	5.00	6.00	6.67	7.33	8.67	6.33
mean	5.58	6.50	7.00	7.67	8.50	9.50	
L.S.D(5%)	**D (1.047)**		**GA_3 (0.933)**		**D×GA_3 (N.S)**		

3.Chlorophyll Index (SPAD): The results in Table 4 show that there were significant differences in leaf chlorophyll Index due to the effect of planting dates and gibberellic acid foliar application. Planting dates significantly affected this trait, with treatment D2 recording the highest chlorophyll index, averaging 47.09 SPAD units, compared to treatment D4, recording the lowest average of 44.43 SPAD units (an increase of 5.99%). This increase can be attributed to favorable temperature and light conditions, which increased the plant's photosynthetic activity, thereby increasing the chlorophyll index. These findings are consistent with the results reported by [16]. Furthermore, the same table shows that gibberellic acid spraying had a significant effect, treatment G5 achieved the highest chlorophyll index with an

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average of 48.67 SPAD units compared to the control (G0), which recorded 39.91 SPAD units (an increase of 21.95%). This superiority is probably due to the role of gibberellic acid in stimulating the plant to increase its absorption of essential nutrients such as nitrogen, phosphorus and potassium, which are basic components in the biosynthesis of chlorophyll molecules. In addition, the physiological ability of GA3 helps to increase the chlorophyll density in the leaves. These results agree with the findings of [19] and. [24] Regarding the interaction between planting dates and gibberellic acid, the results in the same table showed no significant difference for this characteristic, confirming that each factor acts independently.

Table (4). The role of Sowing date and spraying with gibberellic acid on growth and qualitative traits of Faba bean in the trait of leaf chlorophyll index (SPAD).

Concentrations GA^3 / Sowing Dates	G0	G1	G2	G3	G4	G5	mean
D1	41.43	43.73	45.53	46.70	47.20	48.77	45.56
D2	40.40	46.93	47.97	48.33	48.77	50.17	47.09
D3	38.80	44.10	45.40	46.53	46.80	47.97	44.93
D4	39.00	44.10	44.33	45.27	46.07	47.80	44.43
mean	39.91	44.72	45.81	46.71	47.21	48.67	
L.S.D(5%) **D** (1.352) **GA_3** (0.735) **D×GA_3** (N.S)							

4. Nitrogen Concentration in leaves (%): The results in Table 5 confirmed that planting dates, gibberellic acid foliar application and their interaction had significant effects on leaf nitrogen percentage. Planting dates significantly affected this trait, with treatment D2 recording the highest nitrogen percentage, averaging 3.838%, compared to treatment D4, recording the lowest average of 2.364% (an increase of 62.35%). This superiority can be attributed to the favorable environmental conditions at the second planting date, which

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supported strong root growth, leading to increased biological nitrogen fixation through symbiosis with Rhizobium bacteria and subsequently improved nitrogen uptake [33]. Also, the data in the same table showed that gibberellic acid spraying had a significant effect, treatment G5 achieved the highest nitrogen percentage of 3.675% compared to the control (G0) which recorded 2.104% (increase of 74.66%). This increase is probably due to the role of gibberellic acid in stimulating physiological processes in the plant, which increased the absorption of essential nutrients, including nitrogen. These findings are consistent with the results reported by [14] and [17]. Regarding interactions, the results indicated a significant effect between planting dates and gibberellic acid on leaf nitrogen percentage. The highest interaction value was observed in the D2 G5 treatment, reaching 4.563%, while the lowest mean of 1.713% was recorded in the D4 G0 treatment.

Table (5). The role of Sowing date and spraying with gibberellic acid on growth and qualitative traits of Faba bean in nitrogen concentration in leaves (%).

Concentrations GA^3 / Sowing Dates	G0	G1	G2	G3	G4	G5	mean
D1	2.370	3.627	3.670	3.713	3.817	4.393	3.598
D2	2.480	3.877	3.963	4.053	4.093	4.563	3.838
D3	1.853	2.477	2.530	2.557	2.583	3.000	2.500
D4	1.713	2.337	2.390	2.453	2.547	2.743	2.364
mean	2.104	3.079	3.138	3.194	3.260	3.675	
L.S.D(5%)	**D (0.2862)**		**GA_3 (0.1769)**		**D×GA_3 (0.4032)**		

5. Protein Percentage in seed (%): The results presented in Table 6 indicate that Sowing dates, gibberellic acid foliar application and their interaction had significant effects on seed protein percentage.

Planting dates were observed to significantly affect this trait, with the highest protein percentage recorded at the first planting date (D1) being 32.278% compared to treatment D4 which produced the lowest mean of 23.135% (39.52% increase). This is particularly due to the extended duration of both the vegetative and reproductive growth stages. The low number of crop components (pods and seeds) at this date enabled efficient translocation of dry matter from source (leaves) to sink (developing pods) without intense competition for assimilated products. This improved vegetative performance had a positive impact on seed quality (increased protein content) at the expense of quantity. These findings are in line with [7]. Conversely, the decrease in protein percentage at the fourth date (D4) may be due to late sowing, which accelerates plant growth and shortens the life cycle, thereby shortening the pod filling period due to temperature fluctuations. These results agree with [23] and [16]. Furthermore, the same table shows that gibberellic acid application had a significant effect, treatment G5 achieved the highest protein average of 33.155% compared to the control (G0) which recorded 22.057% (an increase of 50.32%). This increase highlights the role of GA_3 in improving seed quality, consistent with the findings of [14]. Regarding the interaction, a significant effect was observed between plantain and gibberellic acid. The highest protein percentage was recorded in the D1 G5 interaction treatment (37.829%), while the D4 G0 treatment gave the lowest mean of 18.725%.

Table (6). The role of Sowing date and spraying with gibberellic acid on growth and qualitative traits of Faba bean in the trait of seed protein percentage (%).

Concentrations GA^3 / Sowing Dates	G0	G1	G2	G3	G4	G5	mean
D1	27.767	30.742	31.004	32.171	34.154	37.829	32.278
D2	21.408	24.150	27.708	29.167	29.138	34.563	27.689
D3	20.329	23.013	24.208	28.583	29.050	31.354	26.090
D4	18.725	21.554	22.750	23.246	23.660	28.875	23.135
mean	22.057	24.865	26.418	28.292	29.000	33.155	
L.S.D(5%)	**D (0.7712)**		**GA_3 (0.4897)**		**D×GA_3 (1.1045)**		

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6.Carbohydrate Percentage in seed (%): The results in Table 7 show that Sowing dates, gibberellic acid foliar application and their interaction had significant effects on seed carbohydrate percentage. Planting dates significantly affected this trait, with the first planting date (D1) recording the highest mean of 49.078%, compared to treatment D4, which produced the lowest mean of 45.365% (an increase of 8.18%). The superiority of the first planting date (D1) is attributed to favorable environmental conditions, including optimal temperature and appropriate light intensity, which enhanced carbohydrate biosynthesis. Conversely, the decrease in carbohydrate percentage at the fourth planting date (D4) may be due to late sowing, which accelerates plant growth and shortens the life cycle, thereby shortening the pod filling period as a result of temperature fluctuations that negatively affect seed weight and carbohydrate content. These findings are in line with [23] and. [16] Furthermore, the same table shows that gibberellic acid spraying had a significant effect, treatment G5 achieved the highest mean of 50.703% compared to the control (G0), which recorded 42.994% (an increase of 17.93%). This increase is due to the positive physiological role of gibberellic acid in promoting growth and increasing carbohydrate accumulation. These results agree with the findings of [24]. Regarding the interaction, the results showed a significant effect between sowing dates and gibberellic acid on carbohydrate percentage. The highest interaction value was observed in the D1 G5 treatment, reaching 52.606%, while the lowest mean of 40.883% was recorded in the D4 G0 treatment.

Table (7). The role of Sowing date and spraying with gibberellic acid on growth and qualitative traits of Faba bean in the trait of seed carbohydrate percentage.

Concentrations GA^3 / Sowing Dates	G0	G1	G2	G3	G4	G5	mean
D1	45.661	47.772	48.994	49.050	50.383	52.606	49.078
D2	44.272	46.772	47.883	48.383	49.994	52.550	48.309
D3	41.161	44.661	46.161	47.994	48.328	48.661	46.161
D4	40.883	44.217	45.217	46.161	46.717	48.994	45.365
mean	42.994	45.856	47.064	47.897	48.856	50.703	
L.S.D(5%)	**D (0.8612)**		**GA_3 (0.4925)**		**D×GA_3 (1.1598)**		

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7. Growing Degree Days (GDD) from Sowing to 100% Flowering: The results in Table 8 indicate that sowing dates, gibberellic acid foliar application and their interaction had significant effects on thermal accumulation (GDD). Planting dates significantly affected this trait, with the first planting date (D1) recording the highest thermal accumulation, averaging 1089.10 °C·days, compared to treatment D4, recording the lowest average of 615.50 °C·days (an increase of 76.95%). This can be attributed to favorable environmental conditions, especially ambient temperature during the growth period up to 100% flowering stage. These findings are consistent with [28, 21 and 6]. Furthermore, the same table shows that gibberellic acid spraying had a significant effect, treatment G5 achieved the lowest thermal accumulation average of 798.01 °C·day compared to the control (G0), which recorded the highest average of 822.58 °C·day. This can be explained by the role of gibberellic acid in stimulating cell division and elongation, thereby increasing plant height, branch number and rapid biomass accumulation. This rapid growth is indirectly linked to plant phenological stages being reached within specific cumulative thermal units. These results agree with the findings of [29] and [27]. Regarding interactions, the results showed a significant effect on thermal accumulation. The highest thermal accumulation value was observed in the D1 G0 treatment (1097.41 °C·day), while the lowest thermal accumulation of 613.79 °C·day was recorded in the D4 G5 treatment.

Table (8). The role of Sowing date and spraying with gibberellic acid on growth and qualitative traits of Faba bean in the trait of thermal accumulation (GDD) at 100% flowering.

Concentrations GA^3 / Sowing Dates	G0	G1	G2	G3	G4	G5	mean
D1	1097.41	1092.26	1090.14	1093.56	1093.28	1067.96	1089.10
D2	820.08	820.08	821.88	824.04	819.80	797.08	817.16
D3	755.71	748.59	750.80	750.80	748.11	713.21	744.54
D4	617.11	615.00	615.00	615.00	617.11	613.79	615.50
mean	822.58	818.98	819.46	820.85	819.57	798.01	
L.S.D(5%)	**D (4.331)**		**GA_3 (6.148)**		**D×GA_3 (11.737)**		

Conclusion

According to the results of this research, The second planting date (October 15) was the appropriate date for planting Faba bean in the conditions of the region, as it excelled in most of its characteristics, growth and Quality. The treatment with gibberellic acid spray also outperformed the level of 250 Mg L^{-1}, recording the highest average for most of the characteristics studied. The Interaction had a significant effect between sowing dates and spraying concentrations.

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