The effect of spraying nano-boron and Appetizer on growth characteristics of *Vicia faba* L.

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ABSTRACT

A field experiment was conducted during the winter season of 2024 at the experimental field of the College of Agricultural Engineering Sciences, University of Baghdad/Al-Jadriyah, to investigate the role of Biostimulator (Biozar) and Nano-Boron in growth and flowering responses of faba bean. The study implemented using Randomized Complete Block Design (RCBD) with three replications, comprising two factorial factors: the first factor involved Nano-Boron foliar application at concentrations of 15, 20, and 25 mg L^{-1}, including a control treatment (water spray), while the second factor consisted of Biostimulator application at concentrations of 2, 4, and 6 mL L^{-1}, in addition to control treatment. The results demonstrated that the 25 mg L^{-1} Nano-Boron concentration significantly exceeded other treatments by achieving the highest mean values for chlorophyll content, and leaf number, reaching 5.69 and 61.15, respectively. Furthermore, the 6 mL L^{-1} Biostimulator concentration from green algae extract exhibited superior performance across most studied traits, particularly chlorophyll content, leaf number, and flower count, with values of 50.92, 64.8, and 61.02, respectively. A noteworthy synergistic effect was observed when Nano-Boron at 25 mg L^{-1} was combined with 6 mL L^{-1} Biostimulator, resulting in a chlorophyll content of 61 SPAD units. In comparison, the combination of 20 mg L^{-1} Nano-Boron with 6 mL L^{-1} Biostimulator proved optimal for leaf number, producing an impressive 81 leaves per plant.

INTRODUCTION

Faba bean is a significant leguminous crop cultivated for its high-nutritional value seeds and holds particular importance for populations in impoverished countries due to its high protein content. Additionally, it serves as animal fodder and plays a crucial role in crop rotation to improve soil characteristics. The total production of faba bean in Iraq reached 9,190 megagrams of fresh and dry beans in 2020 (FAO, 2022). Despite the crop's significance, its productivity remains low due to various factors, including flower abscission, necessitating the development of modern scientific approaches to enhance qualitative and quantitative yields (Abdulrazzaq et al., 2024). Foliar nutrition techniques emerge as a promising strategy, with micronutrients playing a critical role in plant development. Applying appropriate concentrations of nutritional microelements—whether natural or synthetic—during growth stages is both distinctive and essential (Ali, 2012). Foliar nutrition demonstrates superior efficiency compared to soil nutrition, offering higher nutrient utilization and reduced environmental pollution. Nanotechnology represents an innovative approach to developing a new generation of nutrient application with high efficiency, contributing to element

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optimization, toxicity reduction, and mitigating negative consequences associated with excessive fertilizer consumption. Nanofertilizers consequently play a pivotal role in physiological and biochemical processes by providing direct nutrients with rapid leaf penetration. Boron specifically plays a crucial role in pollen tube growth, pollen grain formation, flower setting, cell division, and facilitating carbohydrate transport to active growth regions during plant reproductive stages, with additional significance in protein formation through nitrogen fixation (Bonilla et al., 2009). Despite boron's importance, it remains a slow-moving element within plants, necessitating availability throughout growth stages. Nanotechnology addresses this limitation by generating particles with distinctive properties when dimensions exceed 100 nanometers, offering enhanced element availability through smaller particle sizes and larger surface areas that stimulate photosynthetic processes and absorption surfaces, ultimately improving both qualitative and quantitative production (Saleh, 2015; Singh et al., 2016). Nada and Raam (2023) demonstrated that 100 mg/L nano-boron concentration yielded the highest chlorophyll content, flower number, and branching in mung beans compared to control treatments. Concurrently, sustainable agricultural development strategies emphasizing environmentally safe practices include biofertilizers like marine algae extracts (Biostimulator), characterized as non-toxic, growth-stimulating, economically viable, and environmentally friendly compounds. These extracts are rich in NPK, and micronutrients (Mg, Fe, Mn), and contain proportions of gibberellins and cytokinins (Al-Zubade et al., 2024). Studies by Mohsen and Mahmood (2025) confirmed growth trait responses when applying marine algae extracts compared to non-sprayed controls. Given the significance of nano-nutrition and marine algae extracts, these approaches have emerged as critical research areas, serving as tools to unlock plants' latent physiological potential and ensure optimal crop development.

MATERIAL AND METHODS

A field experiment was conducted in the experimental field of the College of Agricultural Engineering Sciences, University of Baghdad/Al-Jadriyah, located at latitude 33° North and longitude 44° East, during the agricultural season of 2024-2025. The primary objective was to investigate the role of nano-boron and biostimulators in enhancing flower production and growth of faba beans. The experimental design employed a Randomized Complete Block Design (RCBD) with a factorial arrangement and three replications. The first factor involved the foliar application of nano-boron at three concentrations (15, 20, and 25 mg L^{-1}), including a control treatment (water spray), while the second factor consisted of Biostimulator application at three concentrations (2, 4, and 6 mL L^{-1}), also with a control treatment(water spray). This arrangement resulted in 48 experimental units. Spraying was conducted at the 4-5 true leaf stage, approximately one month after planting. Land preparation involved plowing thorough plowing using a moldboard plow, followed by disc harrowing and leveling. The experimental area was divided into units of 2 m^2, with 30 cm spacing between units to prevent treatment cross-contamination. Each experimental unit comprised 5 rows with 20 cm spacing between plants. Urea and triple superphosphate fertilizers were applied according to recommendations (Al-Shakarji, 2010). Spanish variety faba bean seeds were planted

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on 28-10-2024 at a depth of 2 cm. Crop management practices, including weeding, inter-cultivation, and irrigation, were performed as needed. Foliar spraying of Biostimulator and nano-boron was conducted early in the morning using a 16-liter backpack sprayer. Four drops of Zahi surfactant were added to reduce surface tension and enhance spray solution penetration of leaf surfaces. Solutions were prepared at the specified concentrations in the laboratory of Agricultural Engineering Sciences, University of Baghdad.

Studied Traits:

.1 Chlorophyll Content: Measured using a SPAD-502 meter directly in the field during the flowering stage for three plants from each experimental unit.

.2 Leaf Number: Counted for three plants from the central rows, calculating the average number of leaves per plant.

.3 Flower Number: Counted for three plants from each experimental unit, determining the average number of flowers per plant.

.4 Number of Branches: Counted for three plants from the central rows, calculating the average number of branches per plant.

.5 Plant height: Plant height measured from the surface of the soil to the final tip of the plant..

.6 Crop Growth Rate: Calculated from the dry weight sample of three plants using the following equation (Hunt, 1982): CGR = W/T where:

- CGR = Crop Growth Rate
- W = Dry weight of plant sample
- T = Number of days from planting to 100% flowering stage

Statistical Analysis :

Data was statistically analyzed using the Randomized Complete Block Design (RCBD) with the Genstat statistical software. Mean comparisons were performed using the Least Significant Difference (L.S.D.) test at a 0.05 probability level (Steel & Torrie, 1980.(

RESULT AND DISCUSSION:

Chlorophyll Content and Leaf Number Analysis:

The results presented in Table 1 revealed the significant superiority of the 25 mg L^{-1} nano-boron concentration, which provided the highest mean chlorophyll content of 53.02 SPAD units compared to the control treatment's lowest mean of 41.5. For leaf number, the 15 and 20 mg L^{-1} concentrations showed no significant difference, yielding 62.1 leaves, in contrast to the control treatment's lowest mean of 53.1 leaves per plant. The observed increase may be attributed to the unique properties of nanoparticles. When nano-nutrients are foliar-applied to the green mass, they ensure boron availability according to plant requirements and maintain nutrient presence for extended periods. This positively impacts green plastids, cell vitality, cell expansion and division, delays plant tissue senescence, and increases leaf chlorophyll pigmentation by intercepting maximum solar radiation, reflecting positively on leaf number (Ali & Al-Jawhari, 2017). These findings corroborate previous research by Nada (2021) on soybeans and Abdul-Wahab & Al-Hubaity (2017) on faba bean.

Regarding the bio-stimulator, the 6 mL L^{-1} concentration demonstrated superiority by providing the highest chlorophyll content of 50.92 compared to the control treatment's lowest mean of 40.62. It also produced the highest leaf number, an average of 64.8, contrasting with the control treatment's lowest

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mean of 50.7. This increase potentially stems from the Biostimulator's role in biological activities and plant cell activation, attributable to its gibberellin and NPK content, which subsequently increases leaf division and expansion rates, consequently enhancing chlorophyll content and leaf number (Al-Dawdi, 1990.(

The results further indicated a relative interaction response between study treatments. A significant increase was observed when nano-boron (25 mg L^{-1}) was combined with biostimulator (6 mL L^{-1}), achieving a chlorophyll content of 61 SPAD units compared to the control treatment's lowest mean of 47 SPAD units. Additionally, the interaction between 20 mg L^{-1} nano-boron and 6 mL L^{-1} Biostimulator produced the highest leaf number average of 81.4, significantly surpassing the control treatment's mean of 53.8 leaves.

Numbers of branches and flowers.plant-1:

The experimental results in Table 2 revealed significant superiority of 20 and 25 mg L^{-1} nano-boron concentrations in branch development, producing average branch numbers of 6.06 and 5.69 branches per plant, respectively, compared to the control treatment's lowest average of 5.09 branches. Although no statistically significant differences were observed in flower numbers across nano-boron concentrations, the 25 mg L^{-1} concentration yielded the highest flower count of 61.15 flowers per plant, contrasting with the control treatment's 53.92 flowers. The observed morphological enhancement can be attributed to the physiological role of nano-boron and the plant's capacity to utilize it for tissue growth and development, subsequently increasing photosynthetic material production in vegetative sections. The appetizer treatments demonstrated significant effects, with 4 and 6 mL L^{-1} concentrations producing the highest branch averages, potentially due to its nutrient content and gibberellin, which positively influences photosynthetic efficiency and metabolic compound translocation. A relative response was observed in the combined treatment of 25 mg L^{-1} nano-boron and 4 mL L^{-1} appetizer, which produced the highest branch count, while no significant interaction was detected among the studied treatments regarding flower number.

Plant height. Plant-1:

From Table 3, we observe a significant superiority of the 20 mg/L treatment, which provided the highest mean plant height of 46.25 cm compared to the control treatment, which gave the lowest plant height of 40.61 cm. From the same table, we note that the 25 mg/L treatment yielded the highest mean growth rate of 0.85 g•day^{-1}•plant^{-1} compared to the control treatment, which produced the lowest mean plant growth rate of 0.51 g•day^{-1}•plant^{-1}. The increase in plant height may be attributed to the role of nano-boron in accelerating absorption, which enhances enzymatic activity and contributes to increased cell division, elongation, and phloem formation, ultimately reflected in increased cell division and plant height. These results align with Huthily et al. (2021) and Fahem (2022). Boron's role in increasing vegetative growth, such as number of branches, leaves, and plant height (Tables 1, 2, and 3), positively affected the relative growth rate. From the same table, we observe no difference in the effects of optimizer concentrations on plant height, while there was a significant effect on the mean relative growth rate, as the 2 mL/L treatment excelled

without significant difference from other concentrations except the control treatment, which gave the lowest mean relative growth rate of 0.57 g•day^{-1}•plant^{-1}. The table also shows a proportional response between nano-boron and optimizer treatments, with a direct increase between boron and optimizer concentrations in plant height, where the treatment of 20 mg/L and 6 mL/L gave the highest mean height of 47.22 cm, while there was a proportional response of boron with optimizer in affecting the mean growth rate, as the treatment of 25 mg/L boron and 4 mL/L optimizer gave the highest mean of 1.11 g•day^{-1}•plant^{-1}.

CONCLUSION:

The study concluded that elevated concentrations of nano-boron significantly enhanced vegetative growth parameters in fava bean plants. Furthermore, foliar application of plant-derived extracts, particularly those containing green algae components such as the optimizer treatment, proved essential for cultivation practices. The combined application demonstrated a synergistic effect, resulting in noteworthy improvements in the vegetative growth metrics of Vicia faba L. These findings suggest the potential agronomic benefits of incorporating nano-scale boron formulations alongside bio-stimulants in sustainable crop management systems.

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Table 1: Effect of Foliar Application with Nano-Boron, Optimizer, and Their Interaction on Chlorophyll Content in Leaves and Number of Leaves of Fava Bean Plants

Chlorophyll content. plant						Number of leaves. Plant				
Boron concentration ($mg.L^{-1}$)	Appetizer concentration (ml.L)				Average	Appetizer concentration (ml.L)				Average
	O	2	4	6		0	2	4	6	
0	38	39.1	41	43.4	41.5	43.6	49	56.1	63.9	53.1
15	39.7	46.4	45.9	48	44.65	42.7	71.7	70.2	64	62.1
20	37.8	42.1	44.4	51.3	43.4	53.8	53.5	59.7	81.4	62.1
25	47	48.1	56	61	53.02	62.7	49.8	66.3	.50	57.2
L.S.D.0.05	16.91					16.07				
Average	40.62	43.9	46.82	50.92	8.46	50.7	56	63.1	64.8	8.03
L.S.D.0.05	8.46					8.03				

Table 2: Effect of Foliar Application with Nano-Boron, Optimizer, and Their Interaction on Number of Branches and Number of Flowers in Fava Bean Plants

Number of branches						Number of flowers				
Boron concentration ($mg.L^{-1}$)	Appetizer concentration (ml.L)				Average	Appetizer concentration (ml.L)				Average
	O	2	4	6		0	2	4	6	
0	4.20	5.39	5.22	5.55	5.09	59.3	53.8	51.1	51.5	53.92
15	4.78	6.44	6.09	5.33	5.66	55.1	65.4	53	59.1	58.15
20	4.77	5.78	6.11	7.58	6.06	59.1	44.6	67.5	69.4	55,12
25	6.16	5.22	6.33	5.11	5.69	55.3	54.9	70	64.4	61.15
L.S.D.0.05	1.814					ns				ns
Average	4.96	5.71	5.94	5.89	0.907	57.2	54	60.4	61.02	
L.S.D.0.05	0.907					n.s				

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Table 3: Effect of Foliar Application with Nano-Boron, Optimizer, and Their Interaction on Plant Height, and Growth Rate of Fava Bean

Plant height (cm)						Crop growth rate(C.G.R)				
Boron concentration ($mg.L^{-1}$)	Appetizer concentration (ml.L)				Average	Appetizer concentration (ml.L)				Average
	O	2	4	6		0	2	4	6	
0	30.89	43.00	43.55	42.00	40.61	0.40	0.86	0.38	0.41	0.51
15	43.33	43.22	44.33	45.55	44.13	0.47	0.65	0.80	1.36	0.82
20	44.11	47.	46.33	47.22	46.25	0.63	1.08	0.78	0.66	0.79
25	42.22	44.55	44.88	45.22	44.22	0.78	0.99	1.11	0.52	0.85
L.S.D.0.05	9.34					0.45				
Average	40.91	44.52	44.77	45.00	4.67	0.57	0.89	0.77	0.74	0.22
L.S.D.0.05	ns					0.22				

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