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Article

Effect of Organic Fertilizers and Biostimulants on Growth Parameters and Seed Yield of Several Chickpea (*Cicer arietinum L.*) Cultivars

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Abstract: A field trial was carried out in the winter growing season of 2023 at the Agricultural Research and Experimental Center, Department of Field Crops, College of Agriculture, University of Tikrit (Latitude 34.27° N, Longitude 43.35° E), to assess the effects of organic fertilization and biostimulant application on growth characteristics and yield components of three chickpea (Cicer arietinum L.) cultivars. There were two experimental factors involved in this research: first, there were three chickpea cultivars (V1: Flip 99.73C, V2: Flip 99.34C, and V3: Flip 97.70C); second, there were four fertilization treatments: mineral fertilization alone at 20 kg/donum (F1, control), mineral fertilization combined with organic fertilization at 1 ton/donum (F2), mineral fertilization combined with humic acid at 1 g/m2 (F3), and mineral fertilization combined with seaweed extract at 100 g/100 liters/donum (F4). Based on the results obtained, the seaweed extract fertilization treatment (F4) had the best performance regarding plant height (60.06 cm), number of branches per plant (4.52), and seed yield per hectare (2.90 tons). On the other hand, the mineral fertilization treatment combined with organic fertilization (F2) produced the fewest number of days to 50% flowering (73.44 days) and the greatest first pod height (9.66 cm). In terms of cultivar performance, V3 outperformed the other two cultivars in terms of branch number per plant (4.52) and seed yield per hectare (2.90 tons). However, V1 reached 50% flowering earlier than the other cultivars (73.77 days). The interaction between cultivars and fertilization treatments showed significant differences; specifically, the combination of V3 and the seaweed extract fertilization treatment (F4) produced the highest seed yield per hectare (3.35 tons). In conclusion, this study demonstrates that incorporating biostimulants and organic fertilizers into mineral fertilization can improve growth efficiency and yield productivity across various chickpea cultivars.

Keywords: Organic fertilizer, Growth parameters, Yield performance, Chickpea cultivars, Biostimulants.

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1. Introduction

The chickpea (Cicer arietinum L.), a pulse crop of great economic and nutritional importance in the family Fabaceae, has had a major impact on agricultural and food systems throughout the world, especially in those areas that are arid or semi-arid [1]. The importance of the chickpea results from the high nutritional content of the seed. This provides a rich source of plant protein, carbohydrates, dietary fiber, essential minerals, and vitamins. Therefore, the chickpea can provide a significant amount of food security and a cost effective source of protein; also, the chickpea can help diversify the types of crops grown in rotation, and improve soil fertility because of the ability of the chickpea to fix nitrogen from the atmosphere symbiotically through the action of Rhizobium root nodule bacteria [2].

The production of chickpeas is determined by several interrelated genetic, environmental, and management variables; the most important being the cultivar being grown and the level of available soil nutrients. Cultivars differ significantly in their ability to develop, adjust to varying environmental conditions, and take up nutrients from the soil, directly affecting vegetative growth characteristics, yield components, and total yield at maturity [3]. Additionally, genetic differences among cultivars represent a major factor influencing how plants react to alternative methods of fertilization. Therefore, studies that investigate the relationship between genetic factors and nutrient management strategies will be crucial in determining what combination of these factors results in successful plant development and increased yields [3].

Organic fertilization is a key management practice used in agricultural systems to improve the physical, chemical, and biological properties of the soil. Organic fertilizers provide both macro and micronutrients as well as organic materials that can contribute to improving soil structure, increasing soil organic matter content, and improving soil water and nutrient holding capacities. Additionally, organic amendments promote microbial activity in the rhizosphere, promote organic material decomposition in the soil, and gradually release nutrients into the soil solution over time. All of these factors create a positive environment for root growth and development and improve the ability of plants to utilize essential nutrients needed for plant growth and development [4].

The most significant benefits of using organic amendments will be seen in leguminous plants (such as chickpea). Organic amendments will help improve the nutrient environment around the roots of the plant. This will result in an increase in vegetative biomass, branching, and dry matter accumulation, and it will also allow for the optimal conditions for the symbiotic relationship with nitrogen-fixing bacteria. All of these factors will then contribute to an increase in flower initiation, pod formation, seed development and ultimately, an overall improvement in all of the yield components [5].

Recent studies have shown the benefits of incorporating organic nutrients in chickpea farming. Jat et al. [6] found that using 2 tons per hectare (t ha^{-1}) of organic manure along with half of the suggested rate of chemical fertilizers and biofertilizers resulted in greater growth characteristics, yield components and total seed yields as compared to the control group. In addition, Meena and Suman [7] reported that when 75% of the suggested amount of chemical fertilizers was used with 25% organic fertilizer and biofertilizers, there were substantial increases in plant heights, dry matter accumulations, number of pods per plant, 100-seed weights and overall grain yields. Regarding genotypic variations, Nahusenay et al. [8] found that different cultivars exhibited varying degrees of growth, nodulation and yield based on the combinations of genetic backgrounds, Mesorhizobium strains and rates of fertilizer applications; therefore, emphasizing the necessity of developing optimized management practices for each cultivar based on its individual response.

The objective of this research is to examine how different types of fertilizer application affect the performance of different chickpea cultivars. Also, we want to find out which fertilizer-cultivar combination will result in the greatest yield, while considering the climate and environment where our research took place. This is because chickpea is economically and nutritionally important, and the use of organic fertilizer can help improve soil quality.

2. Materials and Methods

2.1 Experimental Site and Soil Analysis

The field experiment took place in the winter agricultural year of 2023 at the Agricultural Research and Experimental Station of the Department of Field Crops within the College of Agriculture at the University of Tikrit (latitude 34.27° N; longitude 43.35° E). This study was designed to investigate the effects of different levels of organic fertilizers and cultivar types both individually and interactively on the growth characteristics and yield components of chickpea.

Prior to planting, soil samples were randomly taken from the study area at a depth of 0–30 cm. Laboratory testing was conducted on these samples in order to identify their

physical and chemical characteristics (Table 1) at the Department of Soil Sciences and Water Resources, College of Agriculture, University of Tikrit..

Table 1. Physical and chemical properties of the experimental soil (0–30 cm depth) prior to planting.

Soil Property	Value
pH	9.08
Electrical Conductivity (ECe, dS m^{-1})	1.84
Sand (%)	86.00
Silt (%)	11.80
Clay (%)	2.20
Available Nitrogen (mg kg^{-1})	14.00
Available Potassium (mg kg^{-1})	160.00
Available Phosphorus (mg kg^{-1})	9.00
Soil Texture	Loamy Sand

2.2 Experimental Factors and Design

The experiment comprised two main factors, as follows:

1. Factor 1: Chickpea Cultivars

Three chickpea cultivars were used in the experiment:

- V1: Flip 99.73C
- V2: Flip 99.34C
- V3: Flip 97.70C

2. Factor 2: Fertilization Treatments

Four fertilization treatments were applied as follows:

Treatment	Fertilization treatments
F1	Mineral fertilizer alone at 20 kg $donum^{-1}$ (Control).
F2	Mineral fertilizer + Organic fertilizer at 1 ton $donum^{-1}$.
F3	Mineral fertilizer + Humic acid at 1 g m^{-2}.
F4	Mineral fertilizer + Seaweed extract at 100 g 100 L^{-1} $donum^{-1}$.

The experimental site was tilled twice in opposite directions with a disc plow; then it was leveled and harrowed so that there could be a seed bed. The experimental design used was a randomized complete block design (RCBD) with a factorial arrangement, which was replicated three times. This gave us a total of 36 experimental units (12 units for each replication). The plots were 1.5 m wide x 6.5 m long (9.75 m^2) and had four rows. Each row was 6.5 m long, had 30 cm between them and 10 cm between plants within each row.

2.3 Agronomic Management

Sowing occurred on November 1st, 2023. Seed rates used for sowing were 2-3 seeds per hill to help create even seedling emergence; these were then thinned to 1 seed per hill 1 month after emergence. Throughout the growing season, irrigation was applied as needed based upon crop water needs. After reaching full maturity, 5 average plants were removed from the center 2 rows of each experimental unit to collect data on growth and yield characteristics.

2.4 Evaluated Parameters

Number of Days From Planting Until 50% of the Plants in Each Plot Bloomed: Number of days from when the plots were planted until half (50%) of the plants in each plot have produced flowers.

Height of Plant (cm plant^{-1}): From the soil surface to the top of the main stem.

Branches per Plant (Branches plant-1): The total number of major reproductive/vegetative branches on each plant.

First Pod Height (cm): The distance between the soil level and the node of the lowest pod on the primary stem.

Seed Yield (t ha^{-1}): Total amount of grain collected from the middle row(s), and then expressed as metric tons per hectare.

2.5 Statistical Analysis

The data collected from this experiment was analyzed using an ANOVA suitable for a factorial RCBD as outlined by Al-Rawi & Khalafallah [9]. The treatment means were then analyzed for significant differences using Duncan's Multiple Range Test (DMRT) with a significance level set at $p <= 0.05$. All statistical analyses were conducted utilizing the SAS software..

3. Results

3.1 Days from Planting to 50% Flowering

There was considerable difference in the average number of days required for 50 percent of the plants to flower among the different types of fertilizer applied to the soil (Table 2). The mineral fertilizer treatment (F1) produced the most extended period before 50 percent of the plants flowered at 75.88 days. In contrast, the application of both mineral and organic fertilizers (F2) resulted in the least amount of time until 50 percent of the plants flowered, taking only 73.44 days. The two other treatments using humic acids (F3) and seaweed extracts (F4) had intermediate results, requiring averages of 74.33 and 74.77 days, respectively.

The accelerated rate of flowering of plants when using organic amendments as opposed to mineral fertilizers only can be explained by several factors, including: the improvement of soil structure through organic matter; an increase in biological activity within the soil; an increase in moisture retention capabilities of the soil; and the promotion of nutrient availability to plants. All these improvements provide for a better rhizosphere environment for plant roots to grow efficiently and develop a higher level of nutritional status that leads to a faster transition from vegetative growth to reproductive development [10].

There were significant differences in the amount of time it took for each of the chickpea cultivars to reach 50% flowering. Cultivar V1 was the earliest to reach 50% flowering at 73.77 days, while cultivar V2 reached 50% flowering in 74.83 days. Cultivar V3 took the longest to reach 50% flowering, with a total of 75.50 days. Genetic make-up, pattern of growth and development, and the degree of sensitivity to environmental cues are some of the major causes of variation in flowering times across chickpea cultivars. The primary factor determining how long a plant remains in its vegetative stage and when it will begin to produce flowers is genetic. The results from this study are similar to those reported by Biset et al. [11] which demonstrated that chickpea cultivars had large differences in their flowering times as a result of both genetic variation and differing responses to micro-climate.

There were significant differences in the interaction of cultivar types and fertilizer rates. Cultivar V2 at treatment F4 had the longest time to flower (77.33 days), while Cultivar V3 at treatment F1 was the next longest (77.00 days). On the other hand, Cultivar V1 at treatment F4 produced flowers earlier than any other combination (72.33 days), and there was no statistically significant difference between this value and that of Cultivar V2 at treatment F2 (72.66 days)..

Table 2. Effect of organic fertilizers, cultivars, and their interaction on days to 50% flowering.

Cultivars	F1	F2	F3	F4	Cultivar Mean
V1	75.55 abc	72.66 c	74.55 abc	72.33 c	73.77 b
V2	75.66 abc	72.66 c	73.66 bc	77.33 a	74.83 a
V3	77.00 ab	75.55 abc	75.33 abc	74.66 abc	75.50 a
Fertilizer Mean	75.88 a	73.44 b	74.33 ab	74.77 ab	-

*Means within columns or rows followed by the same letter do not differ significantly according to Duncan's Multiple Range Test ($p \leq 0.05$).

3.2 Plant Height (cm)

Fertilizers affected plant height significantly (Table 3). Mineral fertilizer combined with seaweed extract (F4) gave the highest mean plant height (60.06 cm), while the control treatment (F1) gave the lowest plant height (55.63 cm). Seaweed extract's effect on plant growth is believed to be due to the presence of bio-active compounds, natural phytohormones (such as auxins and cytokinins), and trace elements which promote cell division and stem elongation [12].

Cultivars showed large variations in their average plant heights. The tallest cultivar was V2 with an average plant height of 54.04 cm. The second tallest was V1 with an average plant height of 51.92 cm. Cultivar V3 had the lowest average plant height at 49.00 cm. These variations demonstrate that there are genetic differences among the cultivars concerning stem elongation, vegetative architecture and adaptation to field conditions [13].

The results of this study showed that the combination of different fertilization methods and cultivars significantly impacted the final plant height. The tallest plants were produced by cultivar V2 in conjunction with seaweed extract (F4), producing a height of 65.50 cm. On the other hand, the shortest plants were produced by cultivar V3 when treated with fertilization method F2, resulting in a height of 48.50 cm.

Table 3. Effect of organic fertilizers, cultivars, and their interaction on plant height (cm).

Cultivars	F1	F2	F3	F4	Cultivar Mean
V1	56.61 d	62.00 bc	49.00 ef	64.17 ab	51.92 b
V2	50.28 f	60.33 c	63.17 a-c	65.50 a	54.04 a
V3	60.00 c	48.50 ef	58.00 bc	50.50 e	49.00 b
Fertilizer Mean	55.63 c	56.94 bc	57.72 b	60.06 a	-

*Means within columns or rows followed by the same letter do not differ significantly according to Duncan's Multiple Range Test ($p \leq 0.05$).

3.3 Number of Branches (branches plant^{-1})

Fertilization treatments significantly affected the number of branches each plant had (Table 4). Mineral fertilization with seaweed extract treatment (F4) had the greatest number of branches per plant (4.52 branches plant-1), whereas the mineral fertilization control treatment (F1) had the fewest number of branches per plant (3.56 branches plant-1). Seaweed extracts have been shown to increase lateral bud growth and branching through the provision of essential nutrients and regulatory signals that affect apical dominance and enhance metabolic vigor [12].

In terms of branch production, there was a significant difference between the different cultivars. Cultivar V3 produced more branches than both V2 and V1, with an average of 4.52 branches per plant compared to 3.84 and 3.47 branches per plant, respectively. The

reason why V3 had the best ability to produce branches can be explained by several factors including the genetic characteristics that control how well axillary buds are activated, how the plant is shaped (canopy architecture) and how effectively the plant moves nutrients from where they are produced (sources) to where they are used (sinks) [14].

A significant relationship was found among the factors. Cultivar V2 when used in conjunction with seaweed extract (F4) resulted in the highest branch count per plant (5.05), while cultivar V1 when used in conjunction with humic acid (F3) had the lowest branch count per plant (3.19).

Table 4. Effect of organic fertilizers, cultivars, and their interaction on the number of branches (branches plant^{-1}).

Cultivars	F1	F2	F3	F4	Cultivar Mean
V1	3.51 cd	3.41 cd	3.19 d	3.75 cd	3.47 c
V2	3.14 d	3.52 cd	3.65 cd	5.05 a	3.84 b
V3	4.02 bc	4.45 ab	4.88 a	4.76 a	4.52 a
Fertilizer Mean	3.56 b	3.79 b	3.91 b	4.52 a	-

*Means within columns or rows followed by the same letter do not differ significantly according to Duncan's Multiple Range Test ($p \leq 0.05$).

3.4 Height of First Pod (cm)

Fertilization had a great effect on how high off the ground the first pod was. The highest placement of the lowest pod was found with the use of organic fertilizer (F2), and it was very similar to using humic acid (F3) or seaweed extract (F4). Organic fertilizers help plants grow longer main stems and longer internodes. This is due to the fact that they allow for more water in the soil and provide better nutrition to roots.

The differences between the cultivars on the basis of first pod height were not found to be statistically significant. Cultivar V1 had a mean height of 9.81 cm, cultivar V2 had 8.87 cm, and cultivar V3 had 8.33 cm. Pod height is mainly influenced by the genetic stem node development and plant height relationship [16].

Regarding interaction effects, cultivar V1 had the greatest first pod clearance when it was treated with organic fertilizer F2 (11.27 cm), while cultivars V2 and V3 both gave the least pod positions when they were treated with organic fertilizer F1 (7.45 cm and 7.50 cm respectively)..

Table 5. Effect of organic fertilizers, cultivars, and their interaction on the height of the first pod (cm).

Cultivars	F1	F2	F3	F4	Cultivar Mean
V1	9.94 c	11.27 a	9.53 abc	8.49 bc	9.81 a
V2	7.45 c	9.25 abc	8.59 bc	10.19 ab	8.87 a
V3	7.50 c	8.47 bc	8.74 abc	8.60 bc	8.33 a
Fertilizer Mean	7.30 b	9.66 a	8.95 a	9.09 a	-

*Means within columns or rows followed by the same letter do not differ significantly according to Duncan's Multiple Range Test ($p \leq 0.05$).

3.5 Seed Yield (t ha^{-1})

The effects of the two main factors and their interactions had a great effect on the seed yield (Table 6). Seaweed extract supplementation (F4) had the best seed yield among all the fertilizer treatments (2.90 t ha-1), however, it was statistically similar to the humic acid

treatment (F3, 2.71 t ha-1). On the other hand, the control treatment (F1) had the worst seed yield (2.15 t ha-1). The increased seed yield caused by seaweed biostimulants can be attributed to improved photosynthesis, increased nutrient uptake, better pod formation, and more efficient seed filling [17].

In terms of genetic superiority among cultivars, V3 was found to be the most superior, producing the highest seed yield at 2.90 t ha^{-1}. V2 came in second with a yield of 2.65 t ha^{-1} while V1 produced the least amount of seed with a yield of 2.10 t ha^{-1}. The superior performance of V3 was due to its greater branching ability, improved pod retention, and efficient assimilation of carbon to the sink organs [18].

The results showed that when cultivar V3 was treated with seaweed extract (F4), it produced the highest seed yield at 3.35 t ha^{-1} and there were no significant differences between the seed yields produced by V3 x F3 (3.10 t ha^{-1}) and V3 x F4. On the other hand, the lowest seed yield was obtained from the combination of V1 x F1 (1.80 t ha^{-1})..

Table 6. Effect of organic fertilizers, cultivars, and their interaction on seed yield (t ha^{-1}).

Cultivars	F1	F2	F3	F4	Cultivar Mean
V1	1.80 f	2.05 ef	2.20 de	2.35 cd	2.10 c
V2	2.25 de	2.50 c	2.85 b	3.00 ab	2.65 b
V3	2.40 cd	2.75 bc	3.10 ab	3.35 a	2.90 a
Fertilizer Mean	2.15 c	2.43 b	2.71 a	2.90 a	-

*Means within columns or rows followed by the same letter do not differ significantly according to Duncan's Multiple Range Test ($p \leq 0.05$).

4. Discussion

The findings of this study demonstrate that organic fertilizers and biostimulants significantly influenced the growth characteristics, flowering behavior, and seed yield of chickpea (*Cicer arietinum* L.) cultivars. The variation observed among fertilization treatments suggests that nutrient availability, soil conditions, and physiological responses play important roles in determining crop productivity. The application of mineral fertilizer combined with seaweed extract (F4) produced the highest plant height (60.06 cm), number of branches per plant (4.52), and seed yield (2.90 t ha^{-1}). These results indicate that seaweed-based biostimulants may enhance vegetative development and reproductive performance by improving nutrient uptake, stimulating metabolic activity, and promoting plant growth processes. The findings are consistent with previous research emphasizing the importance of integrated nutrient management in improving chickpea growth and productivity [5]. Furthermore, the positive responses to combined fertilizer applications support the findings of Jat et al. [6], who reported improved growth and yield characteristics following the integration of organic amendments with mineral fertilizers.

The flowering response differed among fertilization treatments, with the combination of mineral and organic fertilizers (F2) producing the shortest period to 50% flowering (73.44 days), compared with 75.88 days under mineral fertilization alone (F1). This result suggests that organic fertilizer supplementation may accelerate reproductive development by improving soil fertility, nutrient availability, and the root-zone environment. Organic amendments can contribute to favorable soil physical and biological conditions, supporting plant growth and nutrient utilization throughout the growing season [4]. The earlier flowering observed under F2 may therefore reflect improved physiological readiness for reproductive development. Similar improvements in chickpea growth and productivity through the combined application of organic and inorganic fertilizers have been reported by Meena and Suman [7]. Nevertheless, the differences among treatments indicate that the effects of fertilization on flowering are not necessarily identical to those on vegetative growth and final seed yield.

Differences among chickpea cultivars further demonstrated the importance of genetic characteristics in determining responses to fertilization. Cultivar V1 (Flip 99.73C) exhibited the earliest flowering, reaching 50% flowering after 73.77 days, whereas cultivar V3 (Flip 97.70C) produced the highest average number of branches (4.52 branches plant^{-1}) and seed yield (2.90 t ha^{-1}). These findings suggest that early flowering does not necessarily correspond to superior grain productivity. Instead, the greater branching capacity of V3 may have contributed to its reproductive potential and seed production. Genetic variation in vegetative development, nutrient utilization, and yield formation may explain the differences observed among cultivars. Nahusenay et al. [3] similarly reported that chickpea varieties exhibit different growth, nodulation, and yield responses depending on their genetic backgrounds and fertilizer treatments. The present findings therefore highlight the importance of selecting cultivars according to their productive characteristics and compatibility with nutrient management practices.

The interaction between cultivar and fertilization treatment was particularly important in determining seed yield. The combination of cultivar V3 and mineral fertilizer supplemented with seaweed extract (F4) produced the highest seed yield (3.35 t ha^{-1}), followed by V3 combined with humic acid (F3), which yielded 3.10 t ha^{-1}. These two combinations were not significantly different according to the reported multiple-range comparison. In contrast, the lowest yield (1.80 t ha^{-1}) was recorded in cultivar V1 under mineral fertilization alone (F1). This interaction indicates that the effectiveness of nutrient management depends partly on cultivar-specific responses. The superior productivity of V3 under biostimulant treatments may be associated with its relatively greater branching capacity and ability to support reproductive growth. Kara et al. [14] also emphasized the influence of fertilizer and soil-conditioning treatments on yield components among chickpea cultivars. Consequently, cultivar selection and fertilizer management should be considered together when developing strategies to improve chickpea productivity.

The results regarding first pod height also provide important agronomic information. Mineral fertilization combined with organic fertilizer (F2) produced the highest mean first pod height (9.66 cm), while cultivar V1 under the same treatment achieved the greatest individual treatment value (11.27 cm). First pod height is an important morphological characteristic because higher pod placement may facilitate crop harvesting and reduce potential losses associated with pods developing close to the soil surface. Although the differences among cultivar means were not statistically significant, the variation among fertilizer treatments suggests that nutrient management can influence reproductive architecture. Improvements in plant development under integrated fertilizer treatments may be associated with increased nutrient availability and more favorable conditions for stem and reproductive growth. These findings further indicate that optimal fertilization should consider not only total seed yield but also morphological characteristics relevant to crop management.

Overall, the results highlight the potential benefits of integrating organic fertilizers and biostimulants with conventional mineral fertilization for chickpea cultivation. Seaweed extract was particularly effective in improving vegetative characteristics and seed yield, whereas organic fertilizer supplementation promoted earlier flowering and increased first pod height. However, the effectiveness of these treatments varied across cultivars, indicating that fertilizer recommendations should consider the genetic characteristics of the crop. The findings also suggest that biostimulant-based nutrient management may offer a promising approach for improving fertilizer-use efficiency and crop productivity, although these broader benefits were not directly measured in the present experiment. Since the investigation was conducted during one growing season at a single experimental location, further studies across different soil conditions, climatic environments, and growing seasons are necessary to determine the consistency of the observed responses. Additional assessments of nutrient uptake, soil biological activity, fertilizer-use efficiency, and economic returns would also help establish the practical feasibility of integrated fertilization strategies. Taken together, the findings support the combination of cultivar V3 (Flip 97.70C) with mineral fertilizer and seaweed extract as a

promising treatment for improving chickpea seed production under conditions comparable to those of the present study.

5. Conclusion

Organic fertilizer supplementation promoted earlier flowering in chickpea, whereas seaweed extract biostimulants improved vegetative growth, branching, and seed yield. Cultivar V1 reached flowering earliest, while cultivar V3 showed the highest branch density and seed yield. The combination of cultivar V3 with seaweed extract application (F4) achieved the highest seed productivity (3.35 t ha^{-1}), indicating the potential of integrating biostimulants with mineral fertilizers to improve chickpea production under the conditions of this study.

REFERENCES

[1] Jukanti, A. K., Gaur, P. M., Gowda, C. L. L.,, and Chibbar, R. N., "Nutritional composition, health benefits and bio-active compounds of chickpea (Cicer arietinum L.)," Frontiers in Nutrition, 10, 1218468, 2023.

[2] Kumar, N., Hong, S., Zhu, Y., Garay, A., Yang, J., Henderson, D., Zhang, X., Xu, Y.,, and Li, Y., "Comprehensive review of chickpea (Cicer arietinum): Nutritional significance, health benefits, techno-functionalities, and food applications," Comprehensive Reviews in Food Science and Food Safety, 24(2), e70152, 2025.

[3] Nahusenay, G., Wolde, G., Tena, W.,, and Tamiru, T., "Chickpea (Cicer arietinum L.) growth, nodulation, and yield as affected by varieties, Mesorhizobium strains, and NPSB fertilizer in Southern Ethiopia," Frontiers in Plant Science, 15, 1372082, 2024.

[4] Liu, Y., Lan, X., Hou, H., Ji, J., Liu, X.,, and Lv, Z., "Multifaceted ability of organic fertilizers to improve crop productivity and abiotic stress tolerance: review and perspectives," Agronomy, 14(6), 1141, 2024.

[5] Swaroop, D. R., Dhan, J. R., Ram, P.,, and Mo, A., "Optimizing integrated nutrient management (INM) for enhanced growth and yield of chickpea (Cicer arietinum L.) under irrigated conditions," Journal of Experimental Agriculture International, 46(12), 872-881, 2024.

[6] Jat, H. N., Sharma, O. P., Kumar, S., Chaturvedi, V., Singh, G.,, and Bhamboo, K., "Effect of integrated nutrient management on growth, yield and quality of chickpea (Cicer arietinum L.)," Annals of Agricultural Research, 46(3), 275–279, 2025.

[7] Meena, H. O.,, and Suman, B., "Effect of organic and inorganic fertilizers on growth, yield, nutrient uptake and economic returns of chickpea (Cicer arietinum L.)," Journal of Experimental Agriculture International, 47(9), 320–327, 2025.

[8] Nahusenay, G., Wolde, G., Tena, W.,, and Tamiru, T., "Chickpea (Cicer arietinum L.) growth, nodulation, and yield as affected by varieties, Mesorhizobium strains, and NPSB fertilizer in Southern Ethiopia," Frontiers in Plant Science, 15, 1372082, 2024.

[9] Al-Rawi, K. M.,, and Khalafallah, A. A., "Design and Analysis of Agricultural Experiments," Dar Al-Kutub for Printing and Publishing, University of Mosul, Ministry of Higher Education and Scientific Research, Mosul, Iraq, 2000.

[10] Vaheed, M., Bhushan, C., Verma, S. K., Rajpoot, S. K., Shrivastava, S., Verma, A. K.,, and Radha, L., "Response of Crop Growth Rate and Absolute Growth Rate of Late-Sown Chickpea (Cicer arietinum L.) to Nutrient and Weed Management," Journal of Advances in Biology & Biotechnology, 29(9), 269-275, 2026.

[11] Biset, F., Azanaw, M., Amare, A., Jorgi, T.,, and Kindie, M., "Effect of inter-and intra-row spacing on yield and yield components of chickpea [Cicer arietinum (L.)] under residual moisture in Dembia and Takusa Districts, Central Gondar Zone, Ethiopia," Discover Sustainability, 7, 102, 2026.

[12] Das, I., Pradhan, A. K.,, and Singh, A. P., "Yield and yield attributing parameters of organically cultivated mungbean as influenced by PGPR and organic manures," Journal of Crop and Weed, 10(2), 140-144, 2014.

[13] Kumar, A., Kumar, R., Chaurasiya, A., Tekam, Y., Patel, K. K.,, and Dutta, S. K., "Effect of biofertilizer and micronutrients on the growth of chickpeas (Cicer arietinum L.)," Plant Science Today, 12(1), 45-52, 2025.

[14] Kara, Z., Yürürdurmaz, C.,, and Çokkızgın, A., "The effects of fertilizer and different soil conditioner to yield and yield components in chickpea cultivars," Black Sea Journal of Agriculture, 7(3), 180-188, 2024.

[15] Mukherjee, A., Singh, B. N., Gaurav, A. K., Goyal, T., Chouhan, G. K., de Araujo Pereira, A. P., et al., and Verma, J. P., "Plant-microbe interactions of chickpea rhizosphere to modulate microbiome, yields, nutritional quality and soil fertility," Scientific Reports, 16, 4012, 2026.

[16] Ahmed, U., Amanullah, Jamal, A., Ahmad, I., Iqbal, W., Saeed, M. F., et al., and Radicetti, E., "Phosphate-solubilizing bacteria improve phosphorus and zinc availability, chickpea growth, and soil biochemical functioning in calcareous soil," Acta Physiologiae Plantarum, 48(12), 115, 2026.

[17] Shinde, P.,, and Hunje, R., "Influence of soil application of organic manures and foliar spray of liquid biofertilizers on growth and seed yield of Kabuli chickpea (Cicer arietinum L.) varieties," Legume Research, 43(2), 235–240, 2019.

[18] Dhiman, S., Tikoria, R., Ali, M., Kumar, D., Sharma, R., Madaan, I., et al., and Bhardwaj, R., "Revisiting the role of microRNAs in the battle against abiotic stress," In Optimizing Plant Health under Abiotic-Stress Environments (pp. 193-234). CRC Press, 2025.