Interactive Effects of Seed Size and Shifamin BK Foliar Fertilization on Growth and Yield Performance of Faba Bean (*Vicia faba* L.)

Mohammed Jasim Ali

Field Crop Dept., Agriculture College Al-Qasim Green University, Babylon. Iraq

Email: Mohammad.jasim@agre.uoqasim.edu.iq

Abstract:
A field experiment was conducted during the fall season of 2024 at the experimental field of the Department of Field Crops, College of Agriculture, Al-Qasim Green University, located in the south of Babylon Province (latitude 32.40° N, longitude 44.39° E), to investigate the response of *Vicia faba L.* (faba bean) to foliar application of the organic fertilizer Shifamin BK and its effect on seed size. The experiment was arranged in a split-plot arrangement within a randomized complete block design (RCBD) with three replications. The main factor comprised three seed sizes (small, medium, and large), with 100-seed weights ranging from 90–120 g for small seeds, 150–180 g for medium seeds, and 180–240 g for large seeds. The sub-factor consisted of four concentrations of Shifamin BK organic fertilizer (2, 4, and 6 mL·L^{-1}), in addition to a control treatment (spraying with distilled water).

The results of the statistical analysis revealed a significant superiority of large seed size in most studied traits, particularly in field emergence percentage, which was the main parameter of interest, and its relationship with seed size. No significant differences were observed between the 4 and 6 mL·L^{-1} concentrations in terms of field emergence percentage, number of pods per plant, number of seeds per pod, leaf chlorophyll content (SPAD value), and total dry seed yield compared to the control treatment, which recorded the lowest means for these traits, Large seeds exhibited the highest averages across several growth and yield parameters, including field emergence (83.44%), plant height (97.46 cm), 100-seed weight (134.25 g), chlorophyll content (SPAD 51.25), and total dry seed yield (3.64 t ha^{-1}). In contrast, small seeds recorded the lowest averages in these metrics, with values of (77.88%, 88.54 cm, 129.75 g, SPAD 45.82, and 3.20 t ha^{-1}), respectively. Meanwhile, foliar application at a concentration of 6 mL L^{-1} resulted in optimal outcomes, achieving field emergence of (85.56%), plant height of (100.44 cm), an average of (15.02 pods per plant, 100-seed weight of 139.11 g), chlorophyll content of (SPAD 53.67), and total dry seed yield of (3.76 t ha^{-1}). Notably, a significant interaction was observed specifically for the 100-seed weight, where large seeds treated with the 6 mL L^{-1} foliar application achieved the highest mean value of (139.11 g).

In general, it can be concluded that foliar application of Shifamin BK, along with proper spraying timing, can improve yield quality and performance of faba bean when using different seed sizes.

Keywords: Organic Fertilizer; chlorophyll; Shifamin BK; faba bean; seed size

ISSN 2072-3857

Introduction

Foliar spraying of organic fertilizers and biostimulants to improve growth and yield components in faba bean (Vicia faba L.) have been extensively studied in recent years. Application of organic and bio-based fertilizers has been found to increase photosynthesis, nutrient uptake efficiency, and assimilate transport processes through foliar supplementation, thereby stimulating seed development and productivity. For example, foliar application of humic acid enhanced greatly the chlorophyll content, protein rate and seed yield faba bean, and thus it is an important factor in improving physiological performance and seed quality [26].

Likewise, the application of biofertilizers with organic nutrient sources enhanced the vegetative growth traits, 100-seed weight and total seed yield of faba bean, indicating the significance of organic nutrient management strategies in legume production systems [5]. Moreover, foliar application of micronutrients and biostimulants such as zinc and salicylic acid has been reported to improve yield attributes (seed weight & size) through increasing enzymatic activity and photosynthetic efficiency in faba bean plants [1]. The results suggest that foliar application of organic fertilizers can be a sustainable tool to increase seed size and productivity of faba bean under low-nutrient soil availability.

Faba bean (Vicia faba L.) is one of the main annual winter crops in Iraq and one of the main sources of protein food. It is also used for increased soil fertility by atmospheric nitrogen fixation. Moreover, faba bean seeds are rich in carbohydrates (48–54%), minerals, fibers and vitamins [28]. In 2023, the cultivated area of faba bean (green faba bean) reached 16,960 dunums (1 dunum = 1000 m2) and the total yield was 28,181 tones [16].

Faba bean cultivars exhibit varying seed sizes. Seeds are typically categorized as small (1 g per seed). According to both plant breeders and official seed technology associations, seed size is a critical factor for food crop production. Generally, larger seeds possess greater nutrient reserves to support faster germinating and better establishment, ultimately increasing the final yield [11]. Seed size also influences the percentage and rate of seedling emergence, which is closely related to seedling vigor; seedlings depend on their internal reserves before they can independently assimilate nutrients [15].

Natural inputs are increasingly regarded as valuable sources of plant nutrients due to growing environmental concerns associated with synthetic fertilizers and a continuous decline in soil fertility that depletes nutrient reserves. Natural Organic Fertilizers contain essential elements and organic acids that act as hormone-like growth stimulants. These compounds have recently received greater attention as supplementary foliar applications. Previous studies had reported that foliar application of nano-fertilizers increased nutrient content in seeds during flowering and grain filling, thereby improving seed vigor and size [17].

This Study investigates whether larger seeds and higher doses of the organic fertilizer Shifamin BK enhance seedling emergence, vegetative growth parameters, and yield components of faba bean (*Vicia faba* L.) due to improved nutrient availability at these concentrations and enhanced physiological performance. The aim of this research is to examine the role of different faba bean seed sizes on final yield and the effect of cotyledon reserves on seed germination. As well as to assess the effect of organic fertilization in improving quality and characteristics of treated seeds. Ultimately, this study seeks to identify the optimal seed size and concentration of Shifamin BK organic fertilizers can increase yield and accelerate seedling emergence.

Materials and Methods

3.1. Experimental Site and Field

Operations A field experiment was carried out during the fall season of 2024 at the Field Crops Department Farm, College of Agriculture, Al-Qasim Green University, located in southern Babylon Province (32.40° N, 44.39° E). The objective was to study the impact of seed size and foliar application of Shifamin BK organic fertilizer on the growth, yield, and seed quality of a local faba bean variety. The soil was prepared, and the experiment was set up using a Randomized Complete Block Design (RCBD) with a split-plot arrangement across three replications, resulting in a total of 36 experimental units. Standard crop management practices were implemented, including weed control, two thinning operations (at the six-leaf stage and during early pod filling), and surface irrigation adjusted to meet crop water requirements. Prior to planting, soil samples were collected from a depth of 0–30 cm for physical and chemical analysis (Table 1).

Table 1. Some Physical and Chemical Properties of the Experimental Field Soil

Soil texture	Soil Fractions ($g\cdot kg^{-1}$)			Organic Matter ($g\cdot kg^{-1}$ soil)	Available Elements ($mg\cdot kg^{-1}$)			(EC $ds.m^{-1}$)	pH	sample
Mixed	Sand	Loam	Clay		K	P	N			
	252	339	409	7.23	192.21	15.71	35.4	3.72	7.2	Soil

ISSN 2072-3857

3.2. Fertilization Recommendation

Nitrogen fertilization was applied at a rate of 50 kg N ha^{-1} in the form of urea (46% N) in two splits: the first 15 days after sowing and the second one month after the first application. Phosphorus fertilization was applied at a rate of 35 kg P ha^{-1} in the form of triple superphosphate (21% P) as a single dose before sowing [2].

3.3. Studied Factors

The field experiment was conducted using a Randomized Complete Block Design (RCBD) with a factorial arrangement in three replications, comprising 36 experimental units. Each experimental unit measured 1.5 × 1.5 m^2 and included three rows, each containing five plants.

- • Main factor: Three seed sizes of faba bean (small, medium, large) named as S1, S2 and S3. Seed weights per 100 seeds were small (90–120 g), medium (150–180 g) and large (180–240 g).
- Second factor: Four concentrations of Shifamin BK organic fertilizer (0, 2, 4, 6 mL L^{-1}). Foliar sprays were applied early in the morning before sunrise, using a 16-L backpack sprayer under constant pressure. Spraying was conducted in two steps: at the six-leaf stage and at the beginning of pod filling.

3.4. Organic Fertilizer

Shifamin BK is a nitrogenous organic fertiliser rich in amino acids and trace elements containing valuable components. Designed specifically for flowering, fruiting and frost protection of fruit, tuber and bulb crops. It contains important amino acids like arginine, proline, tryptophan and lysine, which are needed for the development of new plant tissues at critical stages of mitosis.

3.5. Studied Traits

3.5.1. Seedling Emergence Percentage (%)

Calculated 14 days after sowing as described by [22].

3.5.2. Plant Height (cm)

Measured using a measuring tape from the soil surface to the top of the plant. The mean of five randomly selected plants from the middle rows of each experimental unit was recorded [20].

3.5.3. Leaf Chlorophyll Content (SPAD)

Chlorophyll content in the leaves was estimated at 50% flowering using a SPAD chlorophyll meter (Spad-502 Plus). Readings were taken from five randomly selected plants, and the mean was recorded [3, 14, 21].

3.5.4. Number of Pods per Plant (pod $plant^{-1}$)

The number of pods was counted for five plants and the mean per plant was calculated.

3.5.5. Number of Seeds per Pod (seed pod^{-1})

The number of seeds in the pods of five plants was recorded, and the mean value was calculated.

3.5.6. 100-Seed Weight (g)

A random sample of 100 healthy, mature, air-dried seeds was taken from each experimental unit after thorough mixing and weighed using a precision balance.

3.5.7. Total Seed Yield (ton ha^{-1})

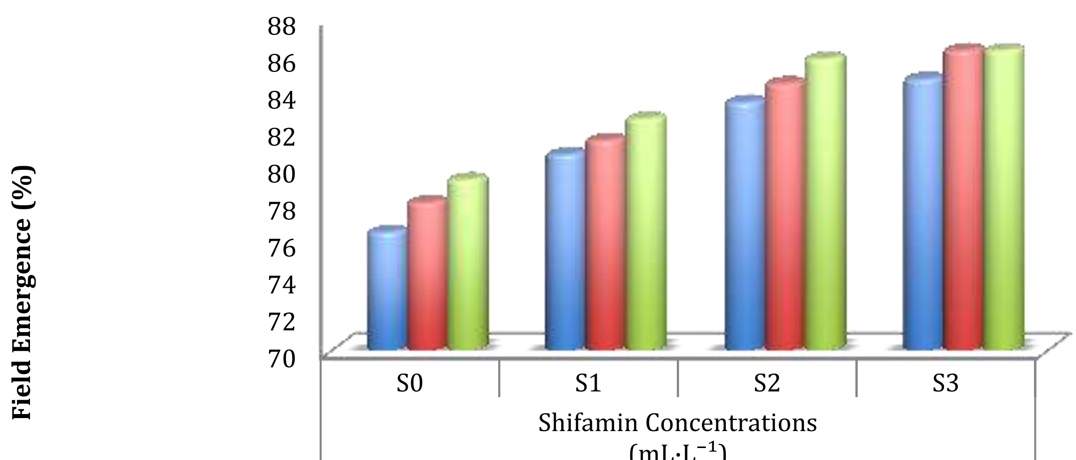
Calculated by multiplying the dry seed yield per plant by the plant density in the field.

3.6. Statistical Analysis

Statistical analysis was performed according to the experimental design using GenStat software. Treatments means were compared using the Least Significant Difference (LSD) test at a 5% probability level [12].

Results and Discussion

The results in Figure (1) revealed significant differences in field emergence percentage due to seed size and foliar application of Shifamin BK. Large seed size recorded the highest mean (83.44%), while the S3 foliar application treatment gave the highest mean (85.56%). The lowest means were observed in small seed size (77.88%) and S0 treatment (81.28%). No significant interaction effects were detected.



	S0	S1	S2	S3
Seed Size (g) Small	76.4	80.6	83.43	84.67
Seed Size (g) Medium	78	81.37	84.43	86.23
Seed Size (g) Large	79.23	82.53	85.77	86.23

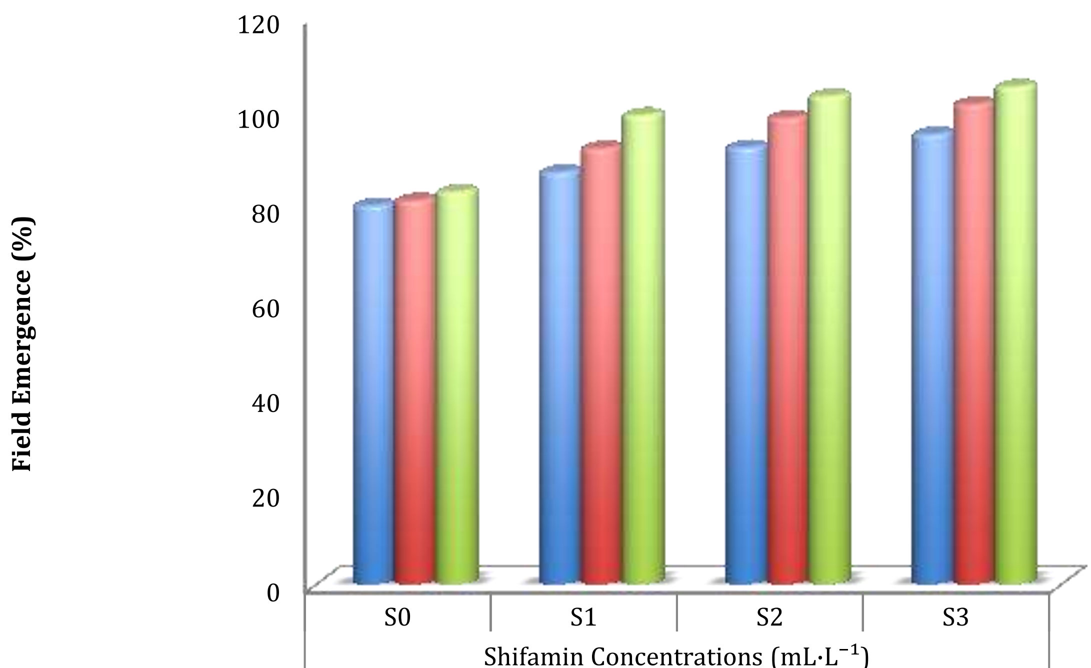
LSD (0.05): Seed size = 1.422, Foliar = 1.575, Interaction = NS

Figure 1. Effect of Seed Size, Foliar Application of Shifamin BK , and Their Interaction on Field Emergence (%)

Significant effects were observed for seed size and Shifamin BK foliar application on plant height. Large seed size recorded the highest mean (97.46 cm), and S3 foliar treatment recorded the highest mean (100.44 cm). The lowest

ISSN 2072-3857

means were recorded for small seed size (88.54 cm) and S0 treatment (81.27 cm). No significant interaction effects were found [6, 23. 24].



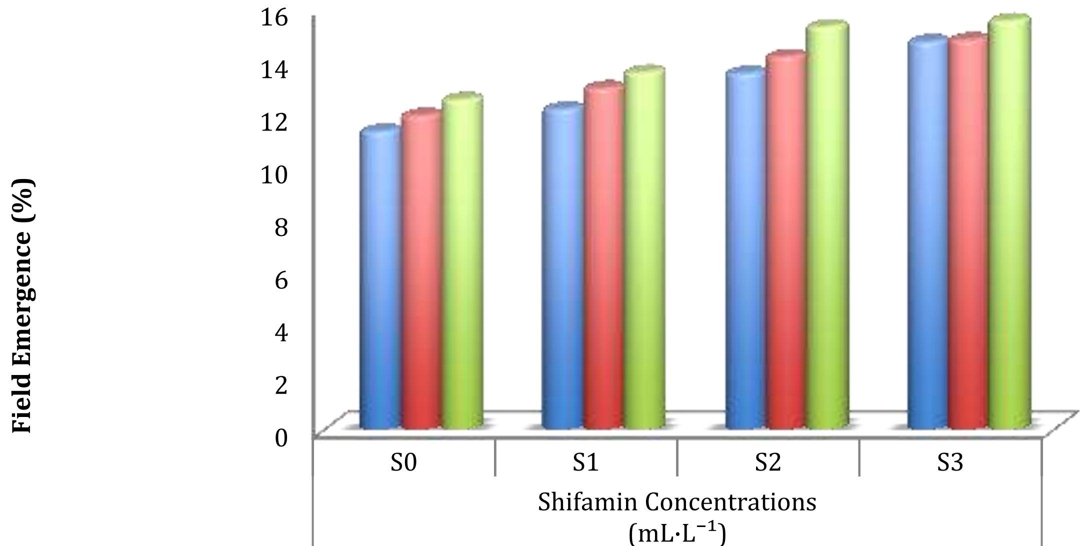
	S0	S1	S2	S3
Seed Size (g) Small	79.97	87	92.2	95
Seed Size (g) Medium	81	92	98.43	101.33
Seed Size (g) Large	82.83	99	103	105

LSD (0.05): Seed size = 1.724, Foliar = 1.952, Interaction = 3.164

Figure 2. Effect of Seed Size, Foliar Application of Shifamin BK, and Their Interaction on Plant Height (cm)

Significant effects were observed for Shifamin BK foliar application on the number of pods per plant. The S3 foliar application treatment recorded the highest mean (15.02), while the lowest mean (81.28) was observed in S0 treatment. No significant effects were detected for seed size or the interaction factor.

ISSN 2072-3857

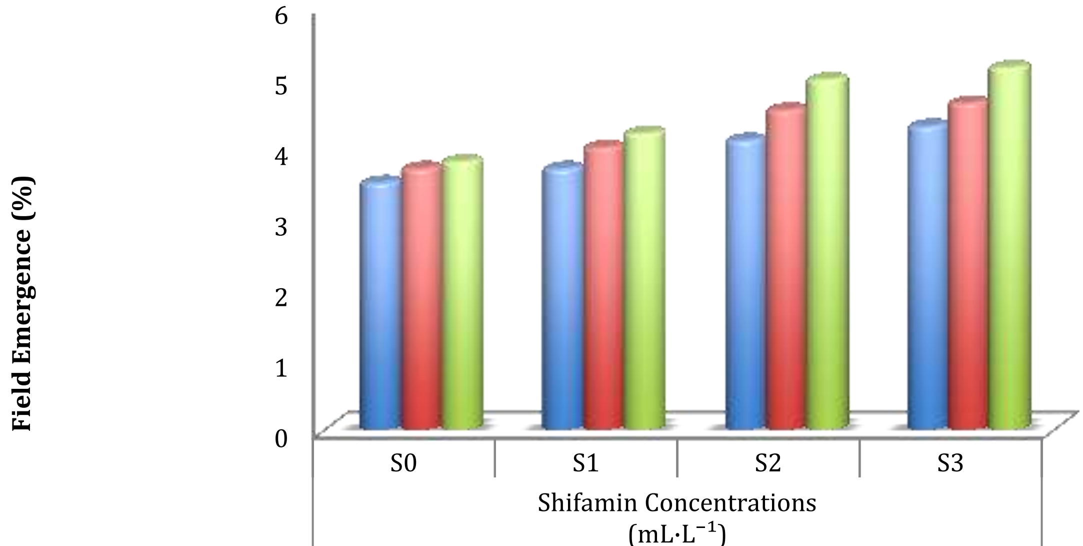


	S0	S1	S2	S3
Seed Size (g) Small	11.33	12.17	13.53	14.73
Seed Size (g) Medium	11.93	12.97	14.17	14.8
Seed Size (g) Large	12.53	13.57	15.3	15.53

LSD (0.05): Seed size = NS, Foliar = 1.663, Interaction = NS

Figure 3. Effect of Seed Size, Foliar Application of Shifamin BK, and Their Interaction on Number of Pods per Plant.

ISSN 2072-3857



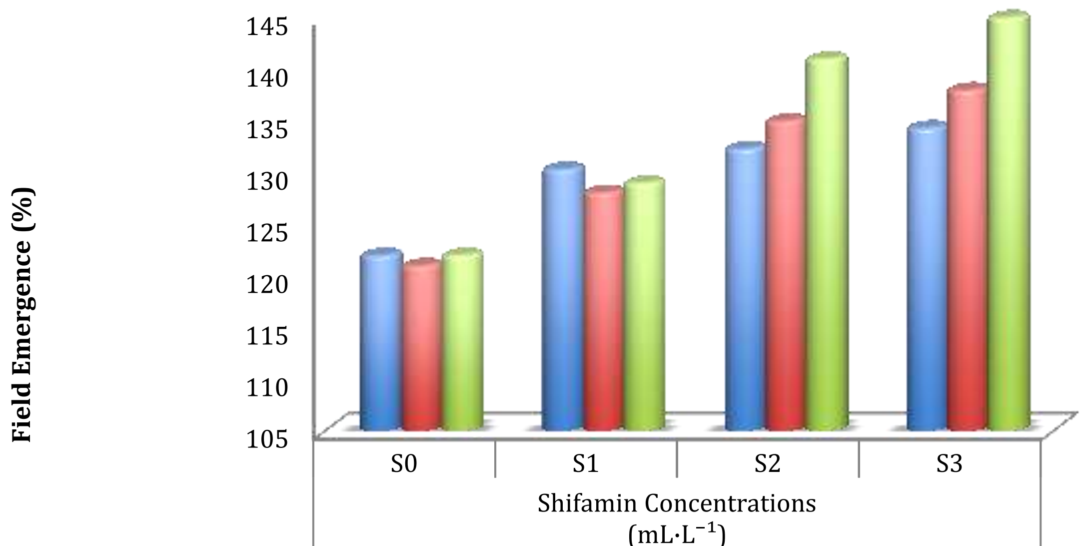
	S0	S1	S2	S3
Seed Size (g) Small	3.5	3.7	4.1	4.3
Seed Size (g) Medium	3.7	4	4.53	4.63
Seed Size (g) Large	3.8	4.2	4.96	5.13

LSD (0.05): Seed size = 0.308, Foliar = 0.303, Interaction = NS

Figure 4. Effect of Seed Size, Foliar Application of Shifamin BK, and Their Interaction on Number of Seeds per Pod

Significant differences were observed for seed size, Shifamin BK foliar application, and their interaction. Large seed size recorded the highest mean (134.25 g), while S3 treatment recorded the highest mean (139.11 g). The lowest means were observed for small seed size (129.75 g) and S0 treatment (121.67 g). The highest mean for interaction was recorded in the S3 × large treatment (139.11 g), while the lowest mean was observed in the S0 × Small treatment (122.00 g).

ISSN 2072-3857

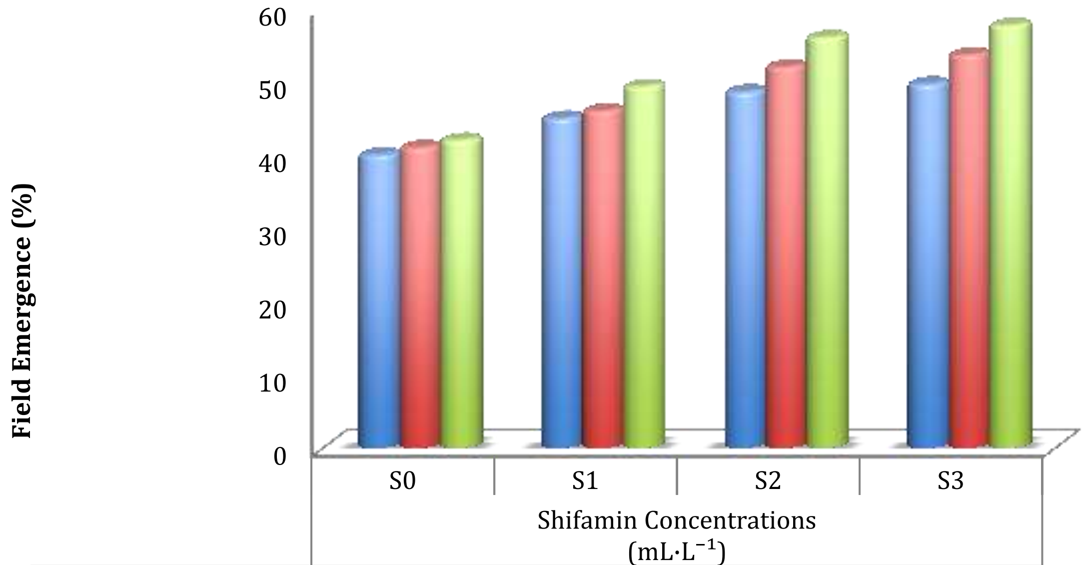


	S0	S1	S2	S3
Seed Size (g) Small	122	130.33	132.33	134.33
Seed Size (g) Medium	121	128.1	135	138
Seed Size (g) Large	122	129	141	145

LSD (0.05): Seed size = 2.351, Foliar = 2.252, Interaction = 3.770

Figure 5. Effect of Seed Size, Foliar Application of Shifamin BK, and Their Interaction on 100-Seed Weight (g)

ISSN 2072-3857



	S0	S1	S2	S3
Seed Size (g) Small	40	45	48.6	49.67
Seed Size (g) Medium	41	46	52	53.67
Seed Size (g) Large	42	49.33	56	57.67

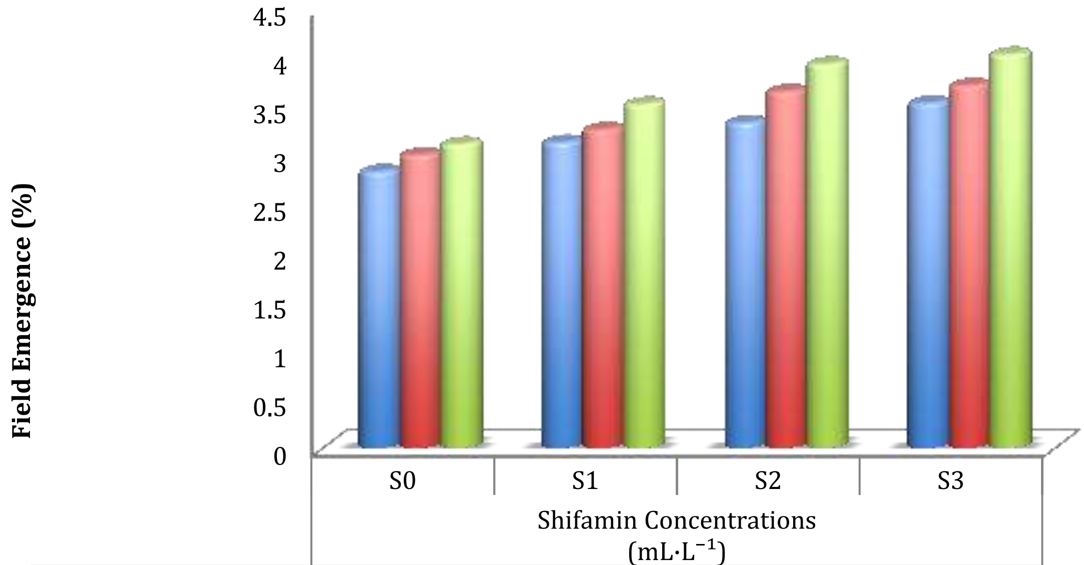
LSD (0.05): Seed size = 1.162, Foliar = 2.561, Interaction = NS

Figure 6. Effect of Seed Size, Foliar Application of Shifamin BK, and Their Interaction on Chlorophyll Content

Significant differences were observed for seed size and foliar application of Shifamin BK. Large seed size recorded the highest mean (51.25), while the S3 treatment gave the highest mean (53.67). The lowest means were recorded for small seed size (45.82) and S0 treatment (41.00). No significant interaction effects were detected.

Significant differences were recorded for seed size and Shifamin BK foliar application. Large seed size recorded the highest mean (3.64 t ha^{-1}), while S3 treatment recorded the highest mean (3.76 t ha^{-1}). The lowest means were observed in small seed size (3.20 t ha^{-1}) and S0 treatment (2.98 t ha^{-1}). No significant interaction effects were detected [7,10].

ISSN 2072-3857



	S0	S1	S2	S3
Seed Size (g) Small	2.83	3.13	3.33	3.53
Seed Size (g) Medium	3	3.26	3.65	3.71
Seed Size (g) Large	3.11	3.52	3.93	4.03

LSD (0.05): Seed size = 0.171, Foliar = 0.178, Interaction = NS

Figure 7. Effect of Seed Size, Foliar Application of Shifamin BK, and Their Interaction on Total Dry Seed Yield (t ha^{-1})

Vegetative Growth Indicators

The results in Tables 2, 3, and 4 indicate significant differences between faba bean seed sizes and Shifamin BK foliar application. This may be attributed to the role of Shifamin BK in enhancing carbon assimilation efficiency as well as regulating and accelerating the transport of assimilates from source (leaves) to sink (seeds), potentially improving seed vigor and subsequent emergence [27]. Large seeds combined with the highest concentration of Shifamin BK outperformed other treatments in most studied traits. Large seeds exhibited greater field emergence due to better nutrient reserves, enabling them to withstand unfavorable conditions, resulting in rapid germination and stronger seedlings [8, 9, and 18].

Plants from large seeds with the highest Shifamin BK concentration also demonstrated maximal plant height and leaf surface area. This was attributed to a rich initial supply of nutrients, which supported an early phase of rapid growth. Furthermore, Shifamin BK's rich amino acids and organic nutrients content increased photosynthesis, developed strong tissue in all parts of the plant, and consequently promoted physiological growth by increasing leaf area and plant height. Increased leaf area enhanced photosynthetic efficiency and thus supported further growth.

ISSN 2072-3857

The applications of Shifamin BK at high concentrations on large seeds also resulted in increased leaf chlorophyll content. This was related to the positive link between sufficient nutrient availability and chlorophyll levels, since nitrogen and magnesium from organic fertilizers are essential for chlorophyll biosynthesis. Increased chlorophyll content supported photosynthetic needs for faster growth vegetative development [13].

Yield Indicators

Dry seed yield and 100-seed weight were significantly higher in superior treatments. Large seeds contained more carbohydrate and protein reserves to support a stronger root system with efficient nutrient uptake. These resulted in increased photosynthesis and assimilate production, which, combined with high Shifamin BK content, contributed to more extensive pod set and seed filling (Table 5, Table 6). Treatments of larger seeds and high concentrations of Shifamin BK were more conducive to obtaining a greater more number of pods per plant by increasing branching and preventing flower abortion [19.25]. Moreover essential micronutrients (Fe, Zn, B &Mo) and amino acids helped prevent flower drop and promoted pod setting [4].

In conclusion, seed size and organic fertilization had a significant effect on faba bean physiological performance. Thus, combining large seed size with an increase in the concentrations of Shifamin BK induces a significant positive impact on vegetative as well as yield components in legume crops.

The findings of this study clearly indicate that faba bean growth and yield attributes were significantly influenced by seed size and foliar application of Shifamin BK organic fertilizer. In most plant traits examined, large seeds were superior due to increased reserves of carbohydrates, proteins, and essential nutrients that benefited early seedling vigor and establishment. This is consistent with a previous reports [11, 18], in which larger seeds favored improved germination and early growth performance.

Shifamin BK with its composition rich in amino acids and micronutrients, favored increased metabolic activities, photosynthesis and translocation of nutrients within the plant, serving as a key factor for the positive response to foliar application. In semi-arid conditions, where crops are often restricted by the alkaline and calcareous nature of soils, foliar feeding proves to be more efficient. Similar results were reported by [26], who documented the positive effect of foliar organic compounds on chlorophyll content and yield.

Furthermore, the absence of significant differences between the higher fertilization levels (4 and 6 $mL \cdot L^{-1}$) for some traits suggested a threshold in nutrient utilization beyond which any benefit from increasing fertilization would be diminished. This highlights the importance of optimizing fertilizer rates for efficient and non-excessive use.

The interaction between foliar fertilization and seed size was, for the majority of tested cases, not significant, although positive trends were observed for larger seeds combined with higher fertilizer concentrations. This illustrates the synergetic action of endogenous seed reserves and exogenous nutrients in improving plant growth and productivity. However, this study was conducted in a controlled environment and over a single growing season only. Therefore, these findings need to be validated in and extrapolated across multiple seasons and environmental settings.

Conclusion

The results of this study indicated that both seed size and foliar application of Shifamin BK significantly affected the growth and productivity of faba bean. Large seeds exhibited superior performance in most measured traits, including field emergence, plant growth, and seed yield, due to their higher nutrient reserves. Foliar application of Shifamin BK enhanced physiological performance and improved yield components, leading to increased seed productivity. Therefore, the use of large seeds in combination with foliar application of Shifamin BK at 4–6 mL L^{-1} can be recommended as an effective agronomic practice for improving faba bean production under semi-arid conditions. Further studies are needed to validate these findings across different environments and growing seasons.

References

[1] Abdel Kader, H. E. (2025). Response of faba bean growth and productivity to foliar

application of salicylic acid and zinc. *Egyptian Journal of Agronomy*. https://journals.ekb.eg/article_443481.html

[2] Aguilera-Díaz, C., & Recalde, M. L. (1995). Effect of plant density and inorganic nitrogen fertilizer on field bean (*Vicia faba* L.). *Agricultural Science, Cambridge*, 125(1), 87–93.

[3] Al Khafagi, K. F. H., Oleiwi, H. S., Abdulhussein, S. S., & Khuit, S. A. (2025). Effect of irrigation periods and mulching on the growth and yield-related traits of maize (*Zea mays* L.). *SABRAO Journal of Breeding and Genetics*, *57*(1), 374–383.

[4] Al-Bayati, A. J. A. (2006). Role of growth regulators Atonik and Hypertonic in reducing flower abscission of faba bean plants and their effect on seed yield. *M.Sc. Thesis*, Department of Field Crops, College of Agriculture, Tikrit University, Iraq.

[5] Alhammad, B. A., & Seleiman, M. F. (2023). Improving plant growth, seed yield, and quality of faba bean by integration of bio-fertilizers with biogas digestate. *Agronomy*, 13(3), 744. https://www.mdpi.com/2073-4395/13/3/744

[6] Ali, J. K., Al-Akkam, A. A., Oleiwi, H. S., & Khuit, S. A. (2026). Effect of L-tyrosine application on anthocyanin accumulation and antioxidant activity in local black rice variety. *Sarhad Journal of Agriculture*, *42*(1), 378–390.

[7] Alkhafagi, H. H. A., Al-Janabi, Y. A., & Al-Khafagi, K. F. H. (2025). Effect of exogenous proline on drought stress tolerance in wheat (*Triticum aestivum* L.) cultivars. *Plant Science Today*, *12*(4).

[8] Alkhafagi, H. H. A., Al-Khafagi, K. F. H., & Al-Janaby, Y. A. (2025). Effectiveness of nano potassium on growth and yield of spring maize (*Zea mays* L.) grown under heat stress. *Pakistan Journal of Agricultural Research*, *38*(2), 18–24.

[9] Al-Khafagi, K. F. H., Al-Wardy, M. I. Z., & Kadim, H. A. A. M. (2023). Effect of foliar potassium on maize yield (*Zea mays* L.). *IOP Conference Series: Earth and Environmental Science*, *1213*(1), 012019. https://doi.org/10.1088/1755-1315/1213/1/012019

[10] Al-Khafagi, K. F. H., Khuit, S. A., & Almaini, A. H. (2020). Response of five bread wheat cultivars to late planting conditions under middle region of Iraq. *Plant Archives*, *20*(2), 990–995.

[11] Alngiemshy, N. F., Alkharafi, J. S., Alharbi, N. S., & Al-Sowayan,

N. S. (2020). Effect of seed size on germination of faba bean plant. *Agricultural Sciences*, 11(5), 457–464.

[12] Al-Rawi, K. M., & Khalafallah, M. K. A. (2000). *Design and analysis of agricultural experiments*. Dar Al-Kutub for Printing and Publishing, University of Mosul, Iraq.

[13] Al-Saabari, H. S. N. (2025). Evaluation of performance of five yellow maize cultivars and estimation of genetic parameters under foliar application of Ciffamin organic fertilizer. *M.Sc. Thesis*, Department of Field Crops, College of Agriculture, Al-Qasim Green University, Iraq.

[14] Al-Wardy, M., Khuit, S., & Al-Khafagi, H. K. K. (2022). The impact of different potassium concentrations on the yield of mungbean (*Vigna radiata* L.). *Revis Bionatura*, *7*(4), 31. https://doi.org/10.21931/RB/2022.07.04.31

[15] Boctes, T. C., & Girardin, P. (1994). Effects of seed size on maize growth from emergence to silking. *Maydica*, 39, 213–218.

[16] Central Statistical Organization (CSO). (2023). *Agricultural statistics*. Ministry of Planning, Republic of Iraq.

[17] Hadi, B. H., & Wuhaib, K. M. (2015). Estimation of genetic parameters of growth and yield characters of yellow maize (*Zea mays* L.) under two nitrogen levels and plant densities. *Egyptian Journal of Applied Sciences*, 30(2), 108–129.

[18] Idris, A. L. Y. (2008). Effect of seed size and plant spacing on yield and yield components of faba bean (*Vicia faba* L.). *Research Journal of Agriculture and Biological Sciences*, 4(2), 146–148.

[19] Issa, F. H., Lamoloom, H. O., & Herby, H. H. (2019). Effect of liquorice extract, yeast suspension and boron on growth and yield of three cultivars of faba bean (*Vicia faba* L.). *International Journal of Agricultural and Statistical Sciences*, 15(1), 18–25.

[20] Jasim, A. H., & Al-Dulaimi, Q. L. (2014). Effect of soil application and foliar spraying of Humic acid and seaweed extract on growth and yield of green pods of faba bean. *Al-Furat Journal of Agricultural Sciences*, 6(1), 163–172.

[21] Jemison, J., & Williams, B. (2006). *Potato–grain study project*. Water Quality Office, Maine Cooperative Extension, 78, 188–195.

[22] Kader, M. A. (2005). A comparison of seed germination calculation formulae and the associated interpretation of resulting data. *Journal and Proceedings of the*

Royal Society of New South Wales, 138, 65–75.

[23] Khuit, S. A., Al Khafagi, K. F., Al-Wardy, M. I. Z., & Abd al Mahdi Kadim, H. (2020). Effect of nitrogen fertilizer and irrigation management on yield of mungbean (*Vigna radiata* L.) under climatic conditions of middle Iraq. *Plant Archives*, *20*(1), 1637–1640.

[24] Khuit, S. A., Al-Ubori, R. S., & Almaini, A. H. (2021). Influence of row spacing on growth and yield of different wheat cultivars. *Indian Journal of Ecology*, *48*, 180–186.

[25] O'Dell, C. (2003). Natural plant hormones as bio stimulants enhancing antioxidant activity for multiple benefits. *Virginia Vegetable, Small Fruit and Special Crops*, 2(6), 1–3.

[26] Roudgarnejad, S., et al. (2022). Improving faba bean seed yield, protein and chlorophyll content by foliar application of humic acid. *Acta Scientiarum Polonorum – Hortorum Cultus*. https://czasopisma.up.lublin.pl/index.php/asphc/article/view/2191

[27] Sadik, S. K., Issa, F. H., & El-Kabbi, E. A. (2016). Effect of gibberellic acid and *Trichoderma* spp. efficiency on seed germination, germination speed, and enzyme activity of two eggplant (*Solanum melongena*) hybrids. *International Journal of Multidisciplinary and Current Research*, 4, 1112–1114.

[28] Yaqub, D., & Nimer, Y. (2011). *Cereal and legume crops production techniques (Theoretical part)*. Damascus University Publications, Faculty of Agricultural Engineering, University of Damascus.

ISSN 2072-3857