Influence of Organic Nutrient and Exogenous Fruit Set Regulator on Floral Development and Yield Performance of Broad Bean

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Abstract
This study evaluated the effects of integrated fertilization and fruit-set regulator spraying on the floral traits and green pod yield of broad bean (Claro de luna). A factorial experiment was arranged in a randomized complete block design with three replications. The first factor consisted of five soil fertilization treatments: 25% of the recommended chemical fertilization (A1); 100% of the recommended chemical fertilization (A2); Karmino Bloom at 3, 4, and 5 L ha^{-1}, each combined with 25% of the recommended NPK fertilization (A3, A4, and A5, respectively). The second factor consisted of ORASET-X spray at 0, 0.3, and 0.6 g L^{-1} (E0, E1, and E2). The combined treatment A5E2 significantly improved floral and yield traits, recording the shortest period to 50% flowering (49.33 days), the highest fruit set (28.65%), pollen viability (91.84%), number of pods per plant (29.02), and early green pod yield (11.02 t ha^{-1}). It was statistically comparable with A2E2 for fresh pod weight (30.65 g), yield per plant (889.50 g), and total green pod yield (39.53 t ha^{-1}). These results indicate that Karmino Bloom at 5 L ha^{-1} combined with 25% of the recommended NPK and ORASET-X at 0.6 g L^{-1} can enhance broad bean productivity while reducing mineral fertilizer input.

Keywords: *Vicia faba*, organic nutrient, NPK, fruit-set regulator, foliar spraying.

Introduction
Broad bean (*Vicia faba L.*) is an important legume crop that is consumed as green pods or dry seeds and is valued for its carbohydrate, protein, vitamin, and amino-acid content [14]. Under Iraqi field conditions, low temperature during the reproductive stage may reduce flowering and pod set, which can negatively affect green pod yield. Balanced nutrient supply and the appropriate use of growth regulators may help improve flowering, fruit set, and final yield. Organic nutrient sources can improve the physical, chemical, and biological properties of the soil and contribute to better nutrient availability [5,13], whereas mineral fertilization remains

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essential for supporting plant growth and yield formation [2]. Auxins are among the plant growth regulators involved in cell division, cell elongation, and reproductive development [25]. In broad bean, foliar application of naphthalene acetic acid (NAA) has been reported to improve flowering, fruit set, pod number, seed yield per plant, and total yield compared with unsprayed plants [29,31]. Therefore, the present study aimed to evaluate the effect of Karmino Bloom combined with 25% of the recommended NPK fertilization and ORASET-X spraying on selected floral traits and green pod yield of broad bean.

Materials and Methods

Broad bean (*Vicia faba L.*) cv. Claro de luna, a Spanish cultivar, was grown under a drip irrigation system. Seeds were sown on 5 October 2023 in experimental units consisting of three rows, with four plants in each row. The spacing was 75 cm between rows and 30 cm between hills. Two seeds were sown per hill and then thinned to one plant per hill, resulting in 12 plants per experimental unit. Two guard rows were planted around the experiment. The experiment was arranged as a factorial experiment in a randomized complete block design (RCBD) with three replications, giving 45 experimental units. The first factor consisted of five soil fertilization treatments: A1 = 25% of the recommended chemical fertilization; A2 = 100% of the recommended fertilization for broad bean (100 kg N, 120 kg P_2O_5, and 100 kg K_2O ha^{-1}); A3 = Karmino Bloom at 3 L ha^{-1} + 25% of the recommended NPK; A4 = Karmino Bloom at 4 L ha^{-1} + 25% of the recommended NPK; and A5 = Karmino Bloom at 5 L ha^{-1} + 25% of the recommended NPK. Karmino Bloom was applied four times according to the company recommendation. The second factor consisted of ORASET-X spray at three concentrations: E0 = 0 g L^{-1}, E1 = 0.3 g L^{-1}, and E2 = 0.6 g L^{-1}. The spray was applied twice, at flowering and after the first harvest. Karmino Bloom contained 8% amino acids, 20% organic matter, 4% organic nitrogen, 4% organic carbon, 3% boron, 3% zinc, and 0.25% molybdenum. ORASET-X contained 1.5% naphthalene acetic acid, 0.45% naphthoxy acetic acid, 85% lactose, and filler materials. Data were analyzed using Genstat software, and treatment means were compared using the least significant difference (LSD) test at $P = 0.05$ [10].

Studied Traits

1. Number of days required for 50% flowering – The number of days from planting until 50% of the plants have flowered.
2. Number of flowers per plant – The total count of flowers produced by each plant.
3. Fruit set percentage (%) – Calculated using the formula:

Fruit set percentage = (Number of set flowers / Total number of flowers) × 100

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4. Pollen viability percentage (%) – Determined using the following formula according to Bruenjes and Link [19].

Pollen viability percentage = (Number of acetocarmine-stained pollen grains / Total number of pollen grains) × 100

5. Number of pods per plant – The total number of pods produced per plant.
6. Fresh pod weight (g) – The average weight of a single pod in grams.
7. Yield per plant (g) – The total green pod yield obtained from a single plant.
8. Early green pod yield (tons ha^{-1}) – The yield calculated from the first three harvests.
9. Total green pod yield (tons ha^{-1}) – The cumulative yield of green pods per hectare.

Results and Discussion

According to Table 1, soil fertilization treatments significantly affected the number of days required for 50% flowering. A5 recorded the shortest period (49.56 days), whereas A1 recorded the longest (58.44 days). ORASET-X spraying did not significantly affect this trait. However, the A × E interaction was significant; A5E2 produced the earliest flowering (49.33 days) and did not differ significantly from A5E1 or A5E0, whereas A1E1 recorded the latest flowering (58.67 days) and did not differ significantly from A1E0 or A1E2.

The number of flowers per plant was significantly affected by both main factors and their interaction (Table 1). A2 produced the highest number of flowers (101.43 flowers $plant^{-1}$), whereas A1 gave the lowest value (78.78 flowers $plant^{-1}$). The highest mean under ORASET-X spraying was obtained with E2 (94.13 flowers $plant^{-1}$). The interaction A2E2 recorded the highest value (102.58 flowers $plant^{-1}$) and was statistically similar to A2E1, whereas A1E0 produced the lowest value (76.59 flowers $plant^{-1}$).

Fruit set percentage followed a similar trend. A5 recorded the highest mean (26.92%), while A1 recorded the lowest value (21.69%). E2 increased fruit set to 25.95% compared with 23.17% in E0. The highest interaction value was obtained with A5E2 (28.65%), whereas A1E0 recorded 19.75%.

Pollen viability was also significantly enhanced by integrated fertilization and regulator spray. A5 recorded 86.49% compared with 71.23% in A1. E2 achieved 83.01%, whereas E0 recorded 75.51%. The highest interaction value was observed in A5E2 (91.84%), while A1E0 produced the lowest value (68.19%).

The positive response may be attributed to the role of amino acids and essential nutrients in the organic nutrient formulation, especially boron and zinc, which support pollen development, fertilization processes, and reproductive performance [7,12,17,20].

Moreover, zinc and amino-acid-derived compounds may contribute to auxin biosynthesis and improve

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nutrient uptake efficiency, thereby enhancing flowering and fruit set [8,9,28].

Table 1. Effects of soil fertilization treatments and ORASET-X spraying on floral traits of broad bean (days to 50% flowering, number of flowers, fruit set percentage, and pollen viability).

Treatments	No. of days to 50% flowering (days)	Number of flowers (flowers $plant^{-1}$)	Fruit set percentage (%)	Pollen viability (%)
A1	58.44	78.78	21.69	71.23
A2	51.44	101.43	26.40	85.44
A3	53.56	89.33	23.87	76.77
A4	51.33	94.47	24.42	78.31
A5	49.56	98.90	26.92	86.49
L.S.D 0.05	0.54	0.57	0.26	0.63
E0	52.93	90.79	23.17	75.51
E1	52.93	92.83	24.87	80.43
E2	52.73	94.13	25.95	83.01
L.S.D 0.05	N. S	0.44	0.20	0.49
A & E Interactions				
A1E0	58.33	76.59	19.75	68.19
A1E1	58.67	79.42	22.52	72.29
A1E2	58.33	80.33	22.80	73.21
A2E0	51.33	99.88	24.59	79.89
A2E1	51.33	101.82	26.68	86.77
A2E2	51.67	102.58	27.94	89.67
A3E0	53.67	87.27	22.84	73.92
A3E1	53.67	89.57	24.12	77.33
A3E2	53.33	91.16	24.66	79.06
A4E0	51.67	93.29	23.25	74.88
A4E1	51.33	94.84	24.30	78.79
A4E2	51.00	95.28	25.72	81.25
A5E0	49.67	96.90	25.35	80.67
A5E1	49.67	98.51	26.75	86.96
A5E2	49.33	101.30	28.65	91.84
L.S.D 0.05	0.94	0.99	0.45	1.10

A1 = 25% of the recommended NPK; A2 = 100% of the recommended NPK (100 kg N, 120 kg P_2O_5 , and 100 kg K_2O ha^{-1}); A3 = Karmino Bloom at 3 L ha^{-1} + 25% NPK; A4 = Karmino Bloom at 4 L ha^{-1} + 25% NPK; A5 = Karmino Bloom at 5 L ha^{-1} + 25% NPK; E0 = no ORASET-X spray; E1 = 0.3 g L^{-1}; E2 = 0.6 g L^{-1}; N.S. = non-significant.

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Table 2 shows that the number of pods per plant increased significantly with fertilization treatments and ORASET-X spraying. A2 produced the highest mean (26.88 pods plant^{-1}) and did not differ significantly from A5 (26.64 pods plant^{-1}), whereas A1 recorded the lowest value (17.11 pods plant^{-1}). E2 gave the highest mean (24.54 pods plant^{-1}), compared with 21.23 pods plant^{-1} in E0. The interaction A5E2 recorded the highest value (29.02 pods plant^{-1}) and did not differ significantly from A2E2, whereas A1E0 produced the lowest value (15.13 pods plant^{-1}). Fresh pod weight was significantly affected by both factors and their interaction. A2 recorded the highest mean (30.40 g), which was statistically similar to A5 (30.33 g), while A1 recorded the lowest value (26.10 g). Among regulator treatments, E2 gave the highest mean (29.24 g), whereas E0 recorded 28.59 g. The interaction A2E2 produced the highest pod weight (31.19 g) and did not differ significantly from A5E2 or A5E1, whereas A1E1 recorded the lowest value (26.05 g). Yield per plant responded similarly. A2 recorded 817.80 g plant^{-1} and did not differ significantly from A5 (808.80 g plant^{-1}), whereas A1 recorded 446.50 g plant^{-1}. E2 increased yield per plant to 724.40 g plant^{-1} compared with 612.10 g plant^{-1} in E0. The highest interaction value was obtained with A2E2 (893.60 g plant^{-1}), which was statistically comparable with A5E2 (889.50 g plant^{-1}), while A1E0 recorded the lowest value (395.10 g plant^{-1}). Early green pod yield was highest in A5 (9.92 t ha^{-1}), with no significant difference from A2 (9.88 t ha^{-1}), whereas A1 recorded the lowest value (5.99 t ha^{-1}). ORASET-X also improved early yield, and E2 recorded 9.14 t ha^{-1} compared with 7.52 t ha^{-1} in E0. The interaction A5E2 produced the highest early yield (11.02 t ha^{-1}) and did not differ significantly from A2E2, whereas A1E0 recorded the lowest value (5.16 t ha^{-1}).

Total green pod yield was significantly affected by both factors and their interaction. A2 recorded the highest mean (36.35 t ha^{-1}) and did not differ significantly from A5 (35.95 t ha^{-1}), whereas A1 recorded the lowest value (19.84 t ha^{-1}). Among regulator treatments, E2 produced the highest total yield (32.19 t ha^{-1}), compared with 27.20 t ha^{-1} in E0.

The interaction A2E2 recorded the highest total yield (39.71 t ha^{-1}), which was statistically similar to A5E2 (39.53 t ha^{-1}), while A1E0 produced the lowest value (17.56 t ha^{-1}). These improvements under integrated nutrient management agree with previous findings reported for mung bean and bean crops [16,24].

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Table 2. Effects of soil fertilization treatments and ORASET-X spraying on yield traits of broad bean (number of pods, fresh pod weight, yield per plant, early green pod yield, and total green pod yield).

Treatments	Number of pods (pods	Fresh pod weight (g)	Yield per plant (g plant^{-1})	Early green pod yield (t ha^{-1})	Total green pod yield (t ha^{-1})
A1	17.11	26.10	446.50	5.99	19.84
A2	26.88	30.40	817.80	9.88	36.35
A3	21.34	28.39	606.30	7.91	26.95
A4	22.98	29.21	671.50	8.20	29.85
A5	26.64	30.33	808.80	9.92	35.95
L.S.D 0.05	0.31	0.48	15.84	0.32	0.70
E0	21.23	28.59	612.10	7.52	27.20
E1	23.21	28.82	674.00	8.48	29.96
E2	24.54	29.24	724.40	9.14	32.19
L.S.D 0.05	0.24	0.37	12.27	0.25	0.55
A & E Interactions					
A1E0	15.13	26.11	395.10	5.16	17.56
A1E1	17.89	26.05	465.70	6.24	20.70
A1E2	18.32	26.13	478.60	6.56	21.27
A2E0	24.82	29.98	744.40	8.87	33.08
A2E1	27.16	30.02	815.40	9.82	36.24
A2E2	28.66	31.19	893.60	10.95	39.71
A3E0	19.93	28.08	559.80	7.15	24.88
A3E1	21.61	28.44	614.90	8.05	27.33
A3E2	22.48	28.65	644.10	8.53	28.63
A4E0	21.69	28.93	627.60	7.61	27.89
A4E1	23.04	29.11	670.90	8.36	29.82
A4E2	24.21	29.58	716.10	8.62	31.83
A5E0	24.57	29.86	733.70	8.81	32.61
A5E1	26.35	30.49	803.30	9.93	35.70
A5E2	29.02	30.65	889.50	11.02	39.53
L.S.D 0.05	0.54	0.83	27.44	0.55	1.22

A1 = 25% of the recommended NPK; A2 = 100% of the recommended NPK (100 kg N, 120 kg P_2O_5, and 100 kg K_2O ha^{-1}); A3 = Karmino Bloom at 3 L ha^{-1} + 25% NPK; A4 = Karmino Bloom at 4 L ha^{-1} + 25% NPK; A5 = Karmino Bloom at 5 L ha^{-1} + 25% NPK; E0 = no ORASET-X spray; E1 = 0.3 g L^{-1}; E2 = 0.6 g L^{-1}; N.S. = non-significant.

The superiority of A5E2 may be related to the combined effect of partial mineral fertilization, organic matter, amino acids, and micronutrients supplied by Karmino Bloom together with the fruit-set regulator. Amino acids may facilitate nutrient absorption and assimilate accumulation, whereas nitrogen contributes to the synthesis of amino acids, proteins, enzymes, and growth-related compounds [18,22,23]. Boron supports carbohydrate transport and reproductive development [3,11,30], while zinc is involved in tryptophandependent auxin synthesis and cell division [1,4]. These combined effects can improve pod development and final yield.

Conclusion

We conclude that Karmino Bloom at 5 L ha^{-1} combined with 25% of the recommended NPK, applied in four doses, together with ORASET-X at 0.6 g L^{-1}, improved flowering, fruit set, pollen viability, and green pod yield of broad bean. This treatment provided performance comparable to full recommended fertilization for several yield traits while reducing mineral fertilizer input. Therefore, the combined use of the organic nutrient and fruit-set regulator may represent a practical approach for improving broad bean productivity under the conditions of this study.

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