Response Growth and Yield Traits of Faba Bean Genotype to Foliar Feeding with Triplex Amino Biostimulator

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Abstract. A field experiment was carried out in the winter season 2019-2020, in the Nuaimiya region of Fallujah city – Al -Anbar Governorate. The aim of the experiment was to study the response of growth and yield traits of faba bean to foliar feeding with Triplex amino biostimulator. The experiment was applied by using a randomized complete block design (RCBD) according to the arrangement of the split-plot with three replicates. The main plots included three genotypes from the remnants (American, Dutch and Italian), While the sub plots included four concentrations of Triplex amino biostimulator (0, 2.5, 5 and 7.5) g L⁻¹. The Dutch genotype recorded the highest average for each of the number of branches in the plant (8.84 branch.plant⁻¹), leaf area (3289.2 cm²), Plant¹, number of pods per plant (19.25 pods. Plant¹), number of seeds per pod (4.56 seed.pod⁻¹) and seed yield (4.263t.h⁻¹). While the American genotype gave the highest average for plant height (106.70 cm) and 100 seed weight (114.5 g.) The biostimulant significantly effect on all growth and yield traits, the concentration 7.5 g. L⁻¹ gave the highest average for each of Plant height (113.29 cm), number of branches per plant (9.88 branch. plant⁻¹ ) , leaf area(3637.9 cm²), Plant¹, number of pods per plant (22.06 pods), number of seeds per pod (4.48 seed.pod⁻¹, weight of 100 seeds (125.2g) and seed yield (4.342 t.h⁻¹). The interaction between the Dutch genotype and concentration 7.5 g. L⁻¹ of the bio stimulant was given the highest average for the number of branches per plant, leaf area, number of pods per plant, and number of seeds per pod.

1. Introduction

Faba bean is the important leguminous crops because their seeds contain a high protein percentage estimated at 25 - 40%, in addition to their seeds contain carbohydrates and many mineral elements, vitamins, amino acids, and others. As a result, this crop is an essential need for humans and animals to make up for animal protein, as it is a cheap source of protein compared to animal protein [1,2]. The faba bean crop has a great physiological and environmental importance, represented by its ability to improve soil properties and improve its granular composition through its contribution to fixing atmospheric nitrogen in the soil through root nodes in coexistence with bacteria Rhizobium legumin Sarum. Therefore, it is used in agricultural rotations [3]. The genotypes of faba bean different in the nature of their growth and morphology, as well as the difference in their effect and the extent of their response to the prevailing environmental factors, can obtained a good yield when there is an appropriate compatibility between the variety, environmental conditions and agricultural processes [4]. The genotypes was not the only factor that leads to the highest productivity, but there are other factors such as foliar feeding with bio- stimulators, including Triplex amino, which is a fast-soluble foliar fertilizer with balanced nutrients used to spray on the leaves and contains macro and micro elements and is fortified with amino acids and organic extracts, this leads to securing the nutrients needed by the plant in a balanced manner and combined in one solution in order to facilitate their absorption by the plant without excessive use of chemical fertilizers that lead to harmful effects on humans and the environment [5]. Triplex amino's containment of amino acids helps protein synthesis quickly and with less energy expenditure, which leads to a better balance between photosynthesis and respiration, and thus better absorption of the elements, biostimulators also increase the plant's ability to withstand environmental stresses by regulating plant content of plant growth regulators such as oxins and gibberellins [6,7]. Which leads to improved plant growth and increased production in quantity and quality. Therefore, this study aims to know the best genotype of the faba bean that response to the foliar feeding with the Triplex amino biostimulator and the interaction between the two workers, which leads to improving the growth and yield characteristics of faba bean crop within the study conditions.
2. Materials and Methods
A field experiment was carried out in the winter season 2019-2020, in the Nuaimiya region of Fallujah city – Al-Anbar Governorate. In order to study the response of the growth and yield traits of faba bean crops to foliar feeding with Triplex amino biostimulator. The experiment was applied using a randomized complete block design (RCBD) according to a split-plot arrangement with three replications. The main plot included three genotypes of faba bean (American (Sakis), Dutch (Aquadulce) and the Italian (Ackerbhone)). While the subplot included four concentrations of Triplex amino biostimulator (0, 2.5, 5, 7.5) g l\(^{-1}\).

Each concentration of the biostimulator was sprayed until the leaves of the plant were completely wet in the early morning using a 15-liter hand spray twice during the growth season, the first was when the height of the plant reached 20 cm, and the second spray was at the beginning of the flowering stage. As for the comparison treatment, it was sprayed with water only. Soil service operations were conducted from plowing, smoothing, leveling and milling, and then divided into experimental units. The experimental unit contained four lines of 3 m length, and the distance between one line and the other was 75 cm and between one plant and another 25 cm. The calibration irrigation was conducted and then the seeds were planted on 12/10/2019 in the upper third of the meadow, 2 seeds were placed in one jar with a depth of 2 cm and the seeds were covered with a light layer of soil, immediately after planting, the experiment was irrigated lightly and the irrigation process continued according to soil moisture and plant need. The failed saplings were planted a week after germination, then the plants were thinned to ensure that one plant remained in one place to obtain a plant density of 53,333 plant h\(^{-1}\). The nitrogen fertilizer was added in the form of urea (46% N) in two batches, the first at planting and the second at the beginning of flowering, at 80 kg. h\(^{-1}\), as for the phosphate fertilizer, it was added in one batch before planting and mixed with soil, at a rate of 120 kg. h\(^{-1}\), the DAP fertilizer (46% P\(_2\)O\(_5\)) was a source for it [8].

Traits Studied
a - Plant height (cm): It was measured at harvest from the plant’s contact area with the soil up to the highest tip of five plants, and then according to the mean.
b - Number of branches per plant: it was calculated as an average of the number of branches in the five plants.
c - Leaf area (cm\(^2\). Plant\(^{-1}\)): When flowering the plants, the leaf area was measured as an average of three leaves for each plant of the five randomly selected plants from each experimental unit, then its average was calculated according to the following equation [9].
\[ LA = 0.04 + 0.45 \text{ (LW)} \]
\[ LA = \text{the leaf area of the plant} \]
\[ L = \text{leaflet length} \]
\[ W = \text{width of the leaf} \]
Then the leaf area is multiplied by the number of leaves per plant to calculate the total leaf area.
d - Number of pods per plant: Calculated as an average of the number of pods taken from the five harvested plants.
e - Number of seeds per pod: 20 pods were taken randomly from each experimental unit and calculated the number of seeds in them and then extracted the average.
f - Weight of 100 seeds (g): 100 seeds were manually counted randomly from each sample taken of five harvested plants from each experimental unit and weighed with a sensitive electronic balance.
g - Seed yield (ton. ha\(^{-1}\)): the individual plant yield was calculated and then multiplied by the plant density to obtain (ton. ha\(^{-1}\)).

2.1. Statistical Analysis
The experiment data were analyzed statistically according to the RCBD design according to the split-plot arrangement using the Genstat program, according to [10], and the arithmetic means of the traits were compared using the least significant difference test (L.S.D) at a probability level of 5%.

3. Results and Discussion

3.1. Plant height (cm)
We note from Table (1) there is a significant effect of the genotypes, biostimulator, and the interaction between them in the traits of plant height. The American genotype gave the highest average of plant height of 106 cm, while the Italian genotype gave the lowest average for the trait was 100.24 cm. The variation between genotypes in plant height may be due to the different genetic nature of it, which is reflected in its different response to soil and crop service processes, and then its difference in this trait [11]. This is Agree with what was found by [12, 13] who showed that the genotypes differ among themselves in the traits of vegetative growth, including plant...
height. It is also noted from the same table, the concentration 7.5 g. L\(^{-1}\) of biostimulator gave the highest average plant height of 113.29 cm, while the comparison treatment gave the lowest average for this trait, which was 93.51 cm. The reason for this may be attributed to the biostimulator containing a nutritional blend that is supplied to the plant, which contributed to cell division and development, and then the elongation of internodes, which led to an increase in plant height, as well as the role of the biostimulator in the production of gibberellin and auxin necessary to elongate cells and then increase plant height [14]. The effect of the interaction between genotypes and biostimulator concentrations was significant on plant height, as the interaction between the American genotype with a concentration of 7.5 g. L\(^{-1}\) was recorded the highest average for this trait was 119.35 cm.

**Table 1.** Effect of genotypes and biostimulator Triplex amino and their interaction in plant height (cm)

| Genotypes | Concentration of biostimulator Triplex amino g.l\(^{-1}\) | Mean |
|-----------|------------------------------------------------------|------|
|           | 0          | 2.5   | 5    | 7.5  |
| American  | 97.05      | 100.30| 110.10| 119.35| 106.70 |
| Dutch     | 88.77      | 95.70 | 106.80| 113.97| 101.31 |
| Italian   | 94.70      | 98.75 | 100.95| 106.55| 100.24 |
| **Mean**  | **93.51**  | **98.25** | **105.95** | **113.29** |
| **L.S.D.0.05** | **G = 4.858** | **B = 2.839** | **G X B = 5.687** |

**3.2. Number of branches per plant**

The results of Table (2) indicate that there are significant differences between the genotypes and the concentrations of the biostimulator and the interaction between them in the number of branches of the plant. The Dutch genotype gave the highest average for this trait at 8.84 branches. Plant\(^{1}\), followed by the Italian genotype, which gave 8.36 branches. While the American genotype gave the lowest average 7.82 branches. Perhaps the reason for the difference in genotypes in this trait is due to its genetic nature in the exploitation of growth factors and its response to the surrounding environmental factors. The results indicate that the high concentration of the biostimulator (7.5) g. L\(^{-1}\) was significantly superiority in giving the highest average for this trait, (9.88 branches). While the comparison treatment gave the lowest number of branches (6.35 branches). The increase achieved in this trait by increasing the concentrations of the biostimulator may be due to the positive role of the micro and macro nutrients, which contributed to increasing the efficiency of the photosynthesis process and the transfer of the products of this representation from the leaves to the active areas in the plant, especially the lateral shoots, which led to an increase in the number of branches in the plant [15,16]. The interaction between the genotypes and the biostimulator was significant, as the Dutch genotype was superior with a concentration of 7.5 g. L\(^{-1}\) by giving the highest average number of branches in the plant, which reached 10.64 branches.

**Table 2.** Effect of genotypes and biostimulator Triplex amino and their interaction in number of branches in the plant

| Genotypes | Concentration of biostimulator Triplex amino g.l\(^{-1}\) | Mean |
|-----------|------------------------------------------------------|------|
|           | 0          | 2.5   | 5    | 7.5  |
| American  | 6.39       | 7.06  | 8.73 | 9.12 | 7.82 |
| Dutch     | 6.11       | 8.67  | 9.95 | 10.64| 8.84 |
| Italian   | 6.56       | 8.67  | 8.31 | 9.89 | 8.36 |
| **Mean**  | **6.35**   | **8.13** | **8.99** | **9.88** |
| **L.S.D.0.05** | **G = 0.329** | **B = 0.468** | **G X B = 0.736** |
3.3. Leaf area (cm². Plant⁻¹)

The results of Table (3) showed that the Dutch genotype gave the highest average leaf area of 3289.2 cm² Plant⁻¹, with a significant increase of 13.48 and 4.22% over the Italian and American genotypes respectively. The superiority of Dutch genotype in this trait is due to its superiority in the number of branches in the plant (Table 2), this was reflected positively in increasing the number of leaves per plant and then increasing the leaf area. This result is agreement with the results of Hillel [17] who found that the genotypes of faba bean differ in leaf area. The results of Table (3) also indicate that the leaf area increased with increasing the concentrations of the biostimulator. The higher concentration of 7.5 g L⁻¹ gave the highest average for this trait, it was 3637.9 cm² Plant⁻¹. While the comparison treatment gave the lowest average of leaf area which was 2331 cm² Plant⁻¹. The reason for this may be attributed to the positive effect of the biostimulator in improving the metabolic processes, which leads to an increase in processed nutrients that affect the increase in cell division and expansion and this led to an increase in the leaf area. This result is in agreement with results of [18]. The interaction between the Dutch genotype and the concentration of 7.5 g L⁻¹ gave the highest mean for leaf area of 3986 cm² Plant⁻¹.

Table 3. Effect of genotypes and biostimulator Triplex amino and their interaction in leaf area of plant (cm²)

| Genotypes | Concentration of biostimulator Triplex amino g.L⁻¹ | Mean |
|-----------|-----------------------------------------------|------|
|           | 0 | 2.5 | 5 | 7.5 |                  |
| American  | 2174.3 | 3131.3 | 3626.3 | 3691.7 | 3155.9 |
| Dutch     | 2636.7 | 2933.7 | 3600.3 | 3968.6 | 3289.2 |
| Italian   | 2182.0 | 2954.7 | 3221.0 | 3236.0 | 2898.4 |
| Mean      | 2331.0 | 3006.6 | 3482.6 | 3637.9 |       |
| L.S.D.0.05 | G = 25.63 | B = 51.66 | G X B = 79.48 |       |

3.4. Number of pods per plant (pod. Plant⁻¹)

It is evident from Table (4) that there is a significant difference between the genotypes in the number of pods per plant. The Dutch genotype gave the highest average for this trait, reaching 19.25 pods Plant⁻¹, and it did not differ significantly from the Italian genotype, which gave an average of 18.62 pods. While the American genotype gave the lowest average number of pods, which was 15.46 pod Plant⁻¹. The superiority of the Dutch genotype in the number of pods may be due to its superiority in the number of branches (Table 2), which led to an increase in the number of pods in the plant. This result is in agreement with results of [19, 20]. We note from the same table that the concentrations of the biostimulator significantly affected in this trait. The concentration of 7.5 g L⁻¹ gave the highest mean of pods, which was 22.06 pods Plant⁻¹, with a significantly increase of 68.91, 29.31 and 16.47% over the comparison treatment and the concentration 2.5 and 5 g L⁻¹. The reason for the superiority of the high concentration of the biostimulator in the number of pods in the plant may be attributed to the positive effect of the biostimulator in improving the metabolic processes, which leads to an increase in processed nutrients that affect the increase in cell division and expansion and this led to an increase in the leaf area. This result is in agreement with results of [18]. The interaction between the Dutch genotype and the concentration of 7.5 g L⁻¹ gave the highest interaction of 24.33 pods Plant⁻¹.

Table 4. Effect of genotypes and biostimulator Triplex amino and their interaction in number of pods per plant

| Genotypes | Concentration of biostimulator Triplex amino g.L⁻¹ | Mean |
|-----------|-----------------------------------------------|------|
|           | 0 | 2.5 | 5 | 7.5 |                  |
| American  | 12.23 | 15.17 | 16.00 | 18.33 | 15.46 |
| Dutch     | 16.00 | 17.33 | 19.33 | 24.33 | 19.25 |
| Italian   | 10.83 | 18.67 | 21.50 | 23.50 | 18.62 |
3.5. Number of seeds per pod (seed. Pod⁻¹)

The results of Table (5) indicate that there was a significant effect of genotypes and biostimulator concentrations on the number of seeds per pod, while the interaction had no significant effect on this trait. The Dutch genotype gave the highest average for the number of seeds per pod, at 4.56 seed. Pod⁻¹, followed by the Italian genotype, which did not differ significantly from it, as it gave 4.26 seed. Pod⁻¹, while the American genotype gave the lowest average for this trait 3.65 seed.pod⁻¹. The reason for the significant difference between genotypes in the number of seeds per pod may be attributed to the different genetic composition. This result is in agreement with results of Ibrahim et al.,[22]. We note from the same table that the high concentration of the biostimulator, 7.5 g. L⁻¹, gave the highest average for number of seeds per pod, amounting to 4.48 seeds. Pod⁻¹, with a percentage increase of 23.08, 7.95 and 2.75% over the concentrations 0, 2.5 and 5 g. L⁻¹ respectively. The reason for this may be due to the biostimulator containing micro elements, including boron, which has a role in increasing flowering nodes, production of pollen and its stability and reducing the abortion of eggs, causing an increase in the fertilization process, which leads to an increase in the number of seeds per pod, because the percentage of fertility in flowers is affected by several factors, some of which are related to genetics, and others related to nutrition [23].

Table 5. Effect of genotypes and biostimulator Triplex amino and their interaction in number of seeds per pod

| Genotypes (G) | Concentration of biostimulator Triplex amino g.l⁻¹ (B) | Mean |
|---------------|----------------------------------------------------|------|
|               | 0                           | 2.5  | 5  | 7.5 |     |
| American      | 2.98                        | 3.71 | 3.91 | 4.01 | 3.65 |
| Dutch         | 4.02                        | 4.51 | 4.76 | 4.95 | 4.56 |
| Italian       | 3.93                        | 4.23 | 4.41 | 4.47 | 4.26 |
| Mean          | 3.64                        | 4.15 | 4.36 | 4.48 |     |

L.S.D.0.05 = G = 0.362 B = 0.424 G X B = ns

3.6. Weight of 100 seeds (g)

The results of Table (6) show that the American genotype gave the highest average weight of 100 seeds, which was 114.5 g, while the Dutch genotype gave the lowest average for this trait, which was 99.8 g. The reason for the superiority of the American genotype in the weight of 100 seeds may be attributed to its giving the lowest average number of seeds per pod (Table 5), and this led to a lack of competition between seeds for nutrients in the stage of their emergence, which affected an increase in their size and thus an increase in their weight. This result is in line with the results of [24, 25] who indicated that the genotypes of faba bean varied in the average weight of 100 seeds. The results of the same table indicate that the concentration of 7.5 g. L⁻¹ recorded the highest average for the weight of 100 seeds, which reached 125.2 g, followed by the concentration of 5 g. L⁻¹, which gave a mean of 114.6 g, while the comparison treatment gave the lowest average for this trait, which was 88.3 g. The reason for the higher concentration of 7.5 g. L⁻¹ may be attributed to its superiority in the leaf area (Table 3), which led to an increase in the efficiency of the photosynthesis process and the transfer of the products of this representation from the source (leaves) to the sink (seeds) to increase their fullness and then increase their weight, in this regard, [21] indicated that the weight of the seed is a function of the rate of photosynthesis and the transmission of its products.

There was a significant interaction between the Study factors, the interaction between the Italian genotype and the concentration of 7.5 g. L⁻¹ gave the highest average weight of 100 seeds, which reached 139.3 g.

Table 6. Effect of genotypes and biostimulator Triplex amino and their interaction in weight of 100 seeds (g)

| Genotypes (G) | Concentration of biostimulator Triplex amino g.l⁻¹ (B) | Mean |
|---------------|----------------------------------------------------|------|
|               | 0                           | 2.5  | 5  | 7.5 |     |
| American      |                               |      |    |     |     |
| Dutch         |                               |      |    |     |     |
| Italian       |                               |      |    |     |     |
| Mean          |                               |      |    |     |     |
American | 101.3 | 114.0 | 115.0 | 127.7 | 114.5
Dutch    | 81.7  | 104.0 | 105.0 | 108.7 | 99.8
Italian  | 82.0  | 98.3  | 123.7 | 139.3 | 110.8
Mean     | 88.3  | 105.4 | 114.6 | 125.2 |

L.S.D. 0.05 | G = 5.38 | B = 6.39 | G X B = 10.28

3.7. Seed yield (ton. ha⁻¹)
The results of Table (7) indicate the superiority of the Dutch genotype in giving the highest average seed yield per unit area, which reached 4.263 ton. ha⁻¹, and it did not differ significantly from the American genotype, which gave 3.903 ton. ha⁻¹, while the Italian genotype gave less average for this trait was 3.150 ton. ha⁻¹. The superiority of the Dutch genotype in seed yield per unit area is due to its superiority in the number of pods per plant (Table 4) and the number of seeds per pod (Table 5) because the final yield of seeds is indicator of its components. This result is in line with results for Mogiso [26]. The same table showed that the seed yield increased significantly with the increase in the concentrations of the biostimulator until it reached its highest average at a concentration of 7.5 g. L⁻¹, which reached 4.342 ton. ha⁻¹, while the comparison treatment gave the lowest average for this trait 3.146 ton. ha⁻¹. The increase in seed yield at the high concentration of the biostimulator was a positive reflection of its significant effect in increasing the number of pods per plant (Table 4), the number of seeds per pod (Table 5) and the weight of 100 seeds (Table 6), which led to an increase in the seed yield per unit area. The interaction between genotypes and biostimulator concentrations was not significant in seed yield.

Table 7. Effect of genotypes and biostimulator Triplex amino and their interaction in seeds yield (ton. ha⁻¹)

| Genotypes (G) | Concentration of biostimulator Triplex amino g. L⁻¹ (B) | Mean |
|---------------|--------------------------------------------------------|------|
|               | 0            | 2.5     | 5       | 7.5       |      |
| American      | 3.404        | 3.781   | 4.199   | 4.227     | 3.903|
| Dutch         | 3.711        | 3.979   | 4.412   | 4.948     | 4.263|
| Italian       | 2.322        | 2.871   | 3.555   | 3.852     | 3.150|
| Mean          | 3.146        | 3.544   | 4.055   | 4.342     |      |
| L.S.D. 0.05   | G = 0.653    | B = 0.593| G X B = ns |

4. Conclusions
It is possible to conclude that the genotypes of the faba bean in this study responded to the concentrations of the Triplex amino biostimulator, and that the Dutch genotype with the concentration was 7.5 g. L⁻¹ gave the highest seed yield, it is also possible in other studies to use these genotypes, and increase the biostimulator concentrations to more than 7.5 g. L⁻¹ to reach the optimal concentration because it has a role in improving plant performance.

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