Fenugreek Performance Affected by Foliar Application of Gibberellin and Arginine Acids

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Abstract. A field experiment was carried out during the winter season of 2020-2021 in a farmer’s field - Zakhikha area - Heet district / Anbar Province, Iraq to find out the effect of four concentrations of GA3, arginine acid and the interaction between them in some growth indicators of fenugreek plant *Trigonellafoenum graecum* L. Split plots via randomized completely block design were used with three replicates. The main plots included GA3 concentrations (0, 100, 200 and 300 mg L-1), while the sub plots included arginine acid concentrations (0, 100, 200 and 300 mg L-1). Results showed that the concentration of 300 mg L-1 for both factors gave a significant increase in plant height, number of branches, plant dry weight, number of pods, 1000 seeds weight and seed yield. Interaction effect between two factors had not a significant effect on all traits except the seed yield which gave an increase rate of 66.53% over the control treatment.

1. Introduction

Modern world has turned to herbal medicine due to the many negatives of manufactured medicines and the ease of using medicinal plants and their availability and multiple benefits such as fenugreek *Trigonellafoenum graecum* L. which belongs to the Fabaceae family. It is a herbal plant that is considered a forage and medicinal crop because of its therapeutic and protective properties against diabetes, liver, stomach, asthma, pulmonary fibrosis, joints and cancer cells [1]; [2]. The importance of fenugreek plants necessitates an increase in the productivity of their vegetative system, seeds and active ingredients through many methods, including spraying of growth regulators which have a great role in the physiological processes. This can be considered an agricultural tool that makes the plant use nutrients efficiently by using low concentrations of spraying to raise its potential physiological and genetic potential to the highest level [3]. GA3 is one of the most important plant growth regulators that increases the photosynthesis process [4], and inhibits the action of the protein DELLA that restricts cell proliferation and expansion [5], in addition to its role in changing maturity, flowering and germination and increasing root length [9]. Spraying of GA3 caused a significant increase in plant height, number of branches, plant dry weight, number of pods, and weight of 1000 seeds of fenugreek [7]. Productivity can also be increased by spraying amino acids, which are the basic structure for building all proteins, and are also the raw materials for the generation of some hormones, purines, pyrimidines, porphyrins and vitamins. Therefore, amino acids have a great importance because they have direct or indirect effects on the physiological processes of the plant through their role in the formation of basic organic compounds for the formation of protoplasm, as well as their participation in the formation of enzymes and energy storage [8]. Among the 21 protein amino acids, arginine contains the highest ratio of nitrogen to carbon,
making it one of the storage forms of organic nitrogen, which is one of the determinants of plant growth and the plants need it in large amount to build the nucleic acids and proteins [9]. Arginine affects the vegetative growth through its role in stimulating the physiological and biological processes that increase the cell building and increase carbohydrates, which are positively reflected on the plant growth, as well as its role in reducing of ABA and increasing the biosynthesis of GA3 and IAA, therefore, arginine increases cell division. [10]; [11]; [12] observed a significant increase in plant height, number of branches and plant dry weight when arginine was sprayed on leaves plant. The aims of this study are to find out the effect of GA3, arginine and the interaction between them on some growth indicators of fenugreek plant.

2. Materials and Methods

A field experiment was carried out during the winter season of 2020-2021 in one of the farmers’ fields - Zakhikha area - Heet district - Anbar Governorate, Iraq, to find out the effect of GA3, arginine and the interaction between them on some growth indicators of fenugreek plant. Experimental land was prepared i.e. plowing and leveling and dividing it into 48 experimental units. The area of each experimental unit was 6 m2 (2 m x 3 m). Split plots according to the system randomized completely block design was used in three replications. The main plots included GA3 concentrations (0, 100, 200 and 300 mg L⁻¹), while the sub plots included arginine acid concentrations (0, 100, 200 and 300 mg L⁻¹). At harvest time, data were recorded by randomly taking five plants from each experimental unit and the studied characters were plant height (cm), number of branches per plant, plant dry weight (g plant⁻¹), number of pods per plants, 1000 seeds weight (g) and seed yield (Kg ha⁻¹). Data were statistically analyzed by using Genestat program and least significant difference (LSD) test at 0.05 probability level was used to compare the treatment means.

3. Results and Discussion

3.1. Plant height (cm)

Results in table (1) indicate that there is a significant increase in plant height with the increases in the concentrations of GA3 spraying. The spraying of GA3 at 300 mgL⁻¹ gave the highest (74.43 cm plant) with an increase of 31.61% compared with control treatment which gave the lowest (56.55 cm plant). The reason of the increase may be due to the role of gibberellins in the synthesis of phenols that inhibit the activity and effect of oxidative enzymes and auxins, thus increasing auxins whose act complements gibberellins in increasing the vegetative growth and plant elongation, as well as the role of gibberellins in increasing the speed of cell divisions in the sub-apical meristem which leads to cells enlarge in size and elongation of the plant. These results are in agreement with [13]. Arginine acid concentrations were significantly different, the spraying of arginine acid at 300 mgL⁻¹ recorded the highest mean (70.22 cm) with an increase of 11.72% compared with the control treatment which recorded the lowest (62.58 cm). The reason of increase could be attributed to the role of arginine acid as a source of nitrogen essential in building proteins and enzymes, in addition to increasing the plant’s ability to absorb water and nutrients and then increasing vegetative growth and plant height [14]. The interaction effect between spraying of GA3 and arginine acid concentrations had non-significant effect on the plant height.

| GA3 (mg L⁻¹) | Arginine (mg L⁻¹) | Means |
|--------------|-------------------|-------|
| 0            | 0                 | 53.27 |
|              | 100               | 54.33 |
|              | 200               | 57.47 |
|              | 300               | 61.13 |
| 100          | 0                 | 62.73 |
|              | 100               | 64.47 |
|              | 200               | 65.73 |
|              | 300               | 70.20 |
| 200          | 0                 | 66.13 |
|              | 100               | 67.93 |
|              | 200               | 68.67 |
|              | 300               | 72.00 |
| 300          | 0                 | 69.27 |
|              | 100               | 74.73 |
|              | 200               | 76.20 |
|              | 300               | 77.53 |
| Means        | 62.85             | 65.37 |
|              |                   | 67.02 |
|              |                   | 70.22 |

Table 1. Effect of GA3 and arginine acid on plant height (cm)
3.2. Number of branches per plant

Results in Table (2) show that there is a significant increase in the number of branches per plant with increasing the concentrations of GA\(_3\) spraying, the spraying of GA\(_3\) at 300 mgL\(^{-1}\) gave the highest (6.93 branch plant\(^{-1}\)) with an increase of 22.28% compared with control treatment which gave the lowest (5.63 branch plant\(^{-1}\)). Reason of the increase may be due to the role of GA\(_3\) in the decomposition of starchy materials and sugars, increasing the cell wall softness and increasing the cells activity, which is positively reflected in the increase in the vegetative system, as well as the role of GA\(_3\) in increasing the plant content of chemicals that increase the transport of nutrients and then increase the growth and development of the plant, including the branches [15]. Arginine acid concentrations were significantly differed, the spraying of arginine acid at 300 mgL\(^{-1}\) had a highest mean (6.59 branch plant\(^{-1}\)) with an increase of 9.28% compared with the control treatment which had the lowest (6.03 branch plant\(^{-1}\)). The reason of the increase may be attributed to the role of arginine acid in providing nitrogen to the plant and reducing the ABA activity in plant, thus increasing cell division and vegetative growth [11].

| GA\(_3\) (mg L\(^{-1}\)) | Arginine (mg L\(^{-1}\)) | Means |
|-------------------------|--------------------------|-------|
| 0                       | 0                        | 5.333 |
| 100                     | 100                      | 5.867 |
| 200                     | 200                      | 5.933 |
| 300                     | 300                      | 5.600 |
| Means                   |                          | 5.683 |

The interaction effect between spraying of GA\(_3\) and arginine acid concentrations had non-significant on the number of branches per plant.

3.3. Plant dry weight (g plant\(^{-1}\))

Results in Table (3) reveal that there is a significant increase in plant dry weight with increasing the concentrations of GA\(_3\) spraying, the spraying of GA\(_3\) at 300 mgL\(^{-1}\) achieved the highest (23.55 g plant\(^{-1}\)) with an increase of 47.92% compared with the control treatment which achieved the lowest (15.92 g plant\(^{-1}\)). The reason may be attributed to the role of GA\(_3\) in stimulating many physiological responses in the plant, as it accelerates the growth of the vegetative system by increasing the elongation and number of cells and then increasing growth and dry weight [16], or the reason of increasing may be due to the superiority of GA\(_3\) at 300 mg L\(^{-1}\) in plant height and number of branches per plant (Tables 1 and 2). Arginine acid concentrations were significantly differed, the spraying of arginine acid at 300 mg L\(^{-1}\) gave the highest (21.88 g plant\(^{-1}\)) with an increase of 20.08% compared with the control treatment which gave the lowest (18.22 g plant\(^{-1}\)). The reason of the increase may be attributed to the role of arginine acid in increasing the plant’s ability to absorb nutrients and increasing plant height and number of branches per plant (Tables 1 and 2), as well as the role of arginine in enhancing the ability of cells to divide and differentiation which increase the plant growth and then dry weight [17]. These results are in agreement with [14]. The interaction effect between spraying of GA\(_3\) and arginine acid concentrations had non-significant effect on the plant dry weight.

| GA\(_3\) × Arginine | LSD 0.05 | 0.3815 | 0.3073 | N.S |
|---------------------|----------|--------|--------|-----|

The interaction effect between spraying of GA\(_3\) and arginine acid concentrations had non-significant effect on the number of branches per plant.
Table 3. Effect of GA$_3$ and arginine acid on plant dry weight (g plant$^{-1}$)

| GA$_3$ (mg L$^{-1}$) | Arginine (mg L$^{-1}$) | Means |
|---------------------|------------------------|-------|
| 0                   | 0                      | 14.47 |
| 100                 | 100                    | 17.47 |
| 200                 | 200                    | 22.13 |
| 300                 | 300                    | 22.27 |
| Means               |                        | 18.22 |

LSD 0.05: 0.959

Table 4. Effect of GA$_3$ and arginine acid on Number of pods per plants

| GA$_3$ (mg L$^{-1}$) | Arginine (mg L$^{-1}$) | Means |
|---------------------|------------------------|-------|
| 0                   | 0                      | 48.00 |
| 100                 | 100                    | 50.00 |
| 200                 | 200                    | 56.47 |
| 300                 | 300                    | 71.07 |
| Means               |                        | 56.38 |

LSD 0.05: 0.959

3.4. Number of pods per plants

Results in Table (4) indicate that there is a significant increase in number of pods per plant with increasing the concentrations of GA$_3$, the spraying of GA$_3$ at 300 mg L$^{-1}$ had the highest (74.43 pod plant$^{-1}$) with an increase of 48.65% compared with the control treatment which had the lowest (50.07 pod plant$^{-1}$). This increase may be due to the physiological properties of GA$_3$ in stimulating the flowering hormone (florigen) and breaking dormant flower buds [3], in addition to its role in distributing nutrients from the vegetative to reproductive parts and increasing the number of flowers and then increasing the number of pods per plant. These results are in line with results of [18]. Arginine acid concentrations significantly differed, the spraying of arginine acid at 300 mg L$^{-1}$ gave the highest mean (68.07 pod plant$^{-1}$) with an increase of 17.36% compared with the control treatment which had the lowest mean. This increase may be attributed to the role of arginine acid in increasing the plant’s ability to absorb nutrients and provide nitrogen, which is mainly involved in building cells through the synthesis of nucleic acids, or the reason of increase could be due to the superiority of the spraying of arginine acid at 300 mg L$^{-1}$ in the number of branches per plant (Table 2). The interaction effect between spraying of GA$_3$ and arginine acid concentrations had non-significant effect on the number of pod per plant.

Table 5. Effect of GA$_3$ and arginine acid on weight of 1000 seeds (g)

| GA$_3$ (mg L$^{-1}$) | Arginine (mg L$^{-1}$) | Means |
|---------------------|------------------------|-------|
| 0                   | 0                      | 19.50 |
| 100                 | 100                    | 20.34 |
| 200                 | 200                    | 21.68 |
| 300                 | 300                    | 22.90 |
| Means               |                        | 21.93 |

LSD 0.05: 0.959

3.5. Weight of 1000 seeds (g)

The results in Table (5) show that there is a significant increase in weight of 1000 seeds with increasing the concentrations of GA$_3$ spraying, the spraying of GA$_3$ at 300 mg L$^{-1}$ achieved the highest (19.50 g weight of 1000 seeds) with an increase of 14.16% compared with the control treatment which achieved the lowest (17.08 g weight). This increase may be attributed to the role of GA$_3$ in redistribution and
transfer of photosynthetic products from the vegetative parts (sources) to the sinks (seeds) which was positively reflected in increasing the seed weight. These results are in agreement with [19]. Arginine acid concentrations significantly differed, the spraying of arginine acid at 300 mg L$^{-1}$ had the highest (19.67 g weight) with an increase of 22.78% compared with the control treatment which gave the lowest (16.02 g weight). This increase may be attributed to the role of arginine acid in increasing the plant’s ability to absorb nutrients, increasing the vegetative growth and then increasing the dry matter and its accumulation in the reproductive parts which led to increasing the weight of the seeds. These results are in agreement with [14]. The interaction effect between spraying of GA$_3$ and arginine acid concentrations had non-significant effect on the weight of 1000 seeds.

Table 5. Effect of GA$_3$ and arginine acid on weight of 1000 seeds (g)

| GA$_3$ (mg L$^{-1}$) | Arginine (mg L$^{-1}$) | Means |
|---------------------|------------------------|-------|
| 0                   | 0                      | 17.08 |
| 100                 | 100                    | 17.67 |
| 200                 | 200                    | 18.58 |
| 300                 | 300                    | 19.50 |
| Means               |                        |       |

LSD 0.05 for GA$_3$, Arginine and GA$_3$ × Arginine

3.6. **Seed yield (Kg ha$^{-1}$)**

The results in Table (6) indicate that there is a significant increase in seed yield with increasing the concentrations of GA$_3$ spraying, the spraying of GA$_3$ at 300 mg L$^{-1}$ gave the highest (1185.6 Kg ha$^{-1}$ yield) with an increase of 39.86% compared with the control treatment which gave the lowest (847.7 Kg ha$^{-1}$ yield). The reason of the increase may be due to the superiority of GA$_3$ at 300 mg L$^{-1}$ in number of pods per plant (Table 4) and weight of 1000 seeds (Table 5). These results are in agreement with [19]. Arginine acid concentrations significantly differed, the spraying of arginine acid at 300 mg L$^{-1}$ recorded the highest mean (1080.7 Kg ha$^{-1}$ yield) with an increase of 19.28% compared with the control treatment which recorded the lowest (906.0 Kg ha$^{-1}$ yield). The reason of the increase could be due to the superiority of the spraying of arginine acid at 300 mg L$^{-1}$ in the number of pods per plant and 1000 seeds weight (Tables 4 and 5). The interaction effect between spraying of GA$_3$, and arginine acid concentrations had a significant effect on the seed yield (Table 6), the spraying of GA$_3$, and arginine acid at 300 mg L$^{-1}$ achieved highest value (1287.3 Kg ha$^{-1}$) with an increase of 66.53% compared with the control treatment which achieved the lowest value (773.0 Kg ha$^{-1}$).

Table 6. Effect of GA$_3$ and arginine acid on seed yield (Kg ha$^{-1}$)

| GA$_3$ (mg L$^{-1}$) | Arginine (mg L$^{-1}$) | Means |
|---------------------|------------------------|-------|
| 0                   | 0                      | 847.7 |
| 100                 | 100                    | 986.1 |
| 200                 | 200                    | 1001.0|
| 300                 | 300                    | 1185.6|
| Means               |                        |       |

LSD 0.05 for GA$_3$, Arginine and GA$_3$ × Arginine
4. Conclusion

In conclusion, spraying gibberellin acid at a concentration of 300 mg. L\(^{-1}\) led to a significant effect on most growth and yield traits compared to the control treatment which gave the lowest value for these traits. Also, spraying the same concentration of arginine acid led to superiority in most growth and yield characteristics, while there was no significant effect on the interaction between the two factors of the study in all traits except for the trait of seed yield, which gave the highest interaction for this trait.

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