Effect of Phenylalanine and Naphthalene Acetic Acid on Growth, Yield and Antioxidant Activity of Fenugreek

*Trigonella foenum-graecum*

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Abstract. A filed experiment was carried out during autumn at 2017 to assess the effect of phenylalanine (Phe) foliar application at a rate of 0, 100 and 200 mg.L-1, and naphthalene acetic acid (NAA) at 0, 50 and 100 mg.L-1, as well as their interactions on growth parameters, yield components and antioxidant activity as a total phenolics content (TPC), total antioxidant capacity (TAC), ferric reducing antioxidant power (FRAP) and radical scavenging activity (DPPH) of leaves and seeds of fenugreek (*Trigonella foenum-graecum* L.). Results showed that all parameters increased significantly with increasing Phe, NAA at 50 mg.L-1 had significant effect on all parameters, while NAA at 100 mg.L-1 increased only plant height and antioxidant activity parameters, the interaction Phe200 × NAA100 gave high values on antioxidant parameters TPC, TAC, FRAP and DPPH reached 166.39, 46.34, 1.298 mg.100g-1 DW and 78.69% respectively for leaves and 64.57, 58.96, 0.504 mg.100g-1 DW and 83.26% respectively for seeds.

1. Introduction
Fenugreek plant (*Trigonella foenum-graecum* L.) is an annual plant, belongs to Fabaceae family, where its leaves are used widely in the diet at many countries, due to its richness of minerals, vitamins (i.e. β-carotene and others), fixed and volatile oils, saponins[1], flavonoids, phenols, alkaloids, fibers, polysaccharides, protein and amino acids[2], the dry leaves and seeds are called spice due to its aroma and blessings to human health and there are many medicinal uses of them as a carminative, tonic, aphrodisiac[3]. Seeds have been also used for the treatment of kidney-related disorders, bronchial complaints, diabetes, painful menstruation, neurasthenia, gout and arthritis. Fenugreek has been substantially, experimentally and medically studies which verified its antidiabetic [4], antioxidant[5], anti-inflammatory [6], anti-pyretic, antiulcer, hypcholestrolaeimic[7], immunomodulatory[8], wound-healing, anticancer[9], gastro protective and chemo preventive effects[3].

Amino acids are very important for stimulating cell growing, which act as a buffer in helping and maintain favorable pH value within the plant cell, since it contains both acid and base groups. The
regulatory role of amino acid Phe is illustrated on plant growth and development via its impact on gibberellins biosynthesis [10]. Phe is partaking with organic nitrogenous compounds on protein synthesis [11], Phe is originator of the phenylpropanoide path leading to the synthesis of phenolic and flavonoids compounds, Phe has been used to growth by provided nitrogen, participation in biosynthesis of protein and all flavonoids pigments [12]. Phytohormones are considered the most important endogenous substances for modulating physiological and molecular responses, and required for plant survival. Phytohormones act either at their site of synthesis or elsewhere in plants following their transport [13]. Hormones adjust physiological system and improvement of vegetation, thus increased dry mass of crop [14].

Naphthalene Acetic Acid (NAA) belongs to synthetic sorts of auxins, which play a key role in cell elongation, division, vascular tissue, differentiation, root initiation, apical dominance, leaf senescence, leaf and fruit abscission, fruit setting and flowering [15]. Many researchers find an important effect of NAA on fenugreek plant height, number of leaves, branches, pods, and seed yield [16, 17]. For that, the current study aimed to examine the influence of exogenously applied (Phe and NAA) on growth, yield and antioxidant activity of leaves and seeds of fenugreek.

2. Materials and Methods
The experiment was carried out in a private farm in Hilla city/Babylon governorate, Iraq within the latitude of 21.44 degrees east and longitude 31.32 degrees north, during winter season of 2017, the soil texture at the experimental site was sandy loam (12.5 silt, 17.5% clay and 70.0% sand) with approximately 1.55% organic matter, pH 7.8, EC 1.27 dSm-1, Nitrogen 60.2 mg.kg-1, Phosphorus 10.8 mg.kg-1 and Potassium 216.7 mg.kg-1. After plowing and leveling the field was added Diamino phosphate fertilizer (contain 48% P and 21% N) at levels 90 kg.ha-1, then dividing into plots (area for each plot) was 6 m2 (2×3 m). Seeds of fenugreek plant variety “Indian locally” were planted on 15 October by hand on lines, the distance between lines was 25 cm and 25 cm between seeds, so each experimental unit had 96 plants, urea fertilizer was added (176 kg.ha-1) in two parts at 14 and 30 days after planting. Phe (0, 100 and 200 mg.L-1) and NAA (0, 50 and 100 mg.L-1) were sprayed at three times: 30, 45 and 60 days after planting, the hand-spray was set during sundown on both leaf surfaces for make totally wet plant to accomplish faster and more effective absorption of Phe and NAA [18]. The experiment design was factorial based on Randomized Complete Block Design (RCBD) with 3 replicates. Data were analyzed using GenStat program, the means were compared by Least significant differences test (LSD) with a probability level 0.05 and using T test when two-sample assuming unequal variances according to [19]. The parameters of growth fenugreek plants were measured at final stage of vegetative growth such as: plant height, branch number, total leaves number, leaf area index, fresh weight, dry weight and total chlorophyll. Yield components were measured at physiological ripening of pods include: pod number, pod length, seed number, weight of 500 seeds, seed yield, fresh leaves productivity, straw productivity and seed productivity. Antioxidant activity of fenugreek in leaves and seeds were measured as follow:

2.1. Extract Preparation
The fenugreek leaves and seeds were cleaned and dried for 24 h in the oven at 50 °C. The dried samples were ground using a mechanical grinder and sieved with a 250 μm mesh. In the extraction process, 100 mg of fenugreek leaves or seeds were 10 ml aqueous solvent of 50% acetone in a universal bottles, samples were homogenized using homogenizer, after that were centrifuged for 10 minute at 3000 rpm[20]. The extract were collected and kept for further analysis.

2.2. Total Phenolics Content (TPC)
Antioxidant activity was assessed using TPC based on the method of [21]. About 0.4 mL distilled water and 0.5 mL diluted Folin-Ciocalteu reagent were mixed with 100 μL samples extracts then set aside for 5 min before 1 mL of 7.5% sodium carbonate (w/v) was added. The absorbance was taken at 765 nm wavelength using a spectrophotometer after 2 h. The calibration spectral curve of gallic acid was used for the estimation of sample activity capacity.

2.3. Total antioxidant capacity (TAC)
The assay turned into primarily based on the reduction of molybdenum (vi) to molybdenum (v) by the pattern and subsequent formation of a green phosphate/molybdenum (v) complex at acidic pH [22]. An aliquot of 0.1 ml of the pattern solution (100 μg/ml) then combined in an eppendorf tube with 1 mg reagent solution (600 mM sulphuric acid, 28 mM sodium phosphate, and 4 mM ammonium molybdate). Then, the samples were incubated in a thermal block at 95°C for 90 min and cooled to room temperature. The absorbance was measured at 695 nm against a blank [23]. The antioxidant ability of extracts is expressed as mg of ascorbic acid.

2.4. Ferric Reducing Antioxidant Power (FRAP)
Antioxidant activity was measured according to the procedure described by [24]. A fresh working FRAP solution was prepared by mixing 300 mM acetate buffer (3.1 g sodium acetate trihydrate plus 16 mL glacial acid made up to 1:1 with distilled water; pH 3.6); 10 mM 2,4,6-tris (2-pyridyl)-s-triazine in 40 mM HCl; and 20 mM FeCl3·6H2O in the ratio of 10:1:1. 1 ml FRAP reagent added to 100 μl fenugreek extracts, and the absorbance were read at 595 nm (after 30 min) using a spectrophotometer. after 30 min. Standard curve Trolox was used to estimate antioxidant activity.

2.5. DPPH Radical Scavenging Activity
140 mg of a 2,2diphenyl-1-picrylhydrazyl (DPPH) dissolved in 350 ml methanol, then mixed with other 350 ml methanol to gain the absorbance of 0.70± 0.01 unit at 516 nm using a spectrophotometer. 100 μl sample extract was added to 1 ml methanolic DPPH solution and incubated in the dark overnight for response [25]. The blank control was also made and the absorbance values were determined using spectrophotometers at 516 nm. Radical scavenging activity (%) was calculated based on the following equation:

\[
\text{Radical scavenging activity (\%) = } \left( \frac{A_{\text{blank}} - A_{\text{sample}}}{A_{\text{blank}}} \right) \times 100
\]

Where: A is the absorbance.

3. Results and Discussions

3.1. Growth Parameters
Results in table 1 indicate that spraying of Phe, NAA and their interactions gave significant effects (P≤0.05) of fenugreek plants during vegetative stages compared to the control. Treatments of Phe were gave more impact when the concentrations were increased, the Phe at concentration 200 mg.L\(^{-1}\) gave the high values on plant height, branch number, total leaf number, leaf area index, fresh weight, dry weight and total chlorophyll which resulted to be 72.59 cm, 6.34 branch.plant\(^{-1}\), 54.13 leaf.plant\(^{-1}\), 2.18 cm\(^2\), 92.45 g.plant\(^{-1}\), 10.21 g.plant\(^{-1}\) and 56.93 SPAD respectively, compared with control (spraying distill water only) which gave 59.94 cm, 5.21 branch.plant\(^{-1}\), 48.73 leaf.plant\(^{-1}\), 1.95 cm\(^2\), 81.92 g.plant\(^{-1}\), 9.06 g.plant\(^{-1}\) and 55.56 SPAD respectively. Whereas NAA treatment at concentration of 50 mg.L\(^{-1}\) resulted highest values on growth parameters, which reached 6.29 branch.plant\(^{-1}\), 56.69 leaf.plant\(^{-1}\), 2.283 cm\(^2\), 77.78 g.plant\(^{-1}\) 8.64 g.plant\(^{-1}\) and 55.76 SPAD respectively, compared with control which gave 5.60 branch.plant\(^{-1}\), 46.72 leaf.plant\(^{-1}\), 1.873 cm\(^2\), 77.78 g.plant\(^{-1}\), 8.64 g.plant\(^{-1}\) and 55.76 SPAD respectively,
but NAA at concentration 100 mg.L\(^{-1}\) was resulted highest values on plant height which gave to be 69.93 cm compared with control which gave 58.71 cm. The interaction treatment Phe 200 mg.L\(^{-1}\)× NAA 50 mg.L\(^{-1}\) gave the highest values on growth parameters, which resulted to be 6.86 branch.plant\(^{-1}\), 60.18 leaf.plant\(^{-1}\), 2.409 cm\(^2\), 100.33 g.plant\(^{-1}\), 11.03 g.plant\(^{-1}\) and 57.59 SPAD respectively, compared with control (spraying distilled water only) which gave 5.06 branch.plant\(^{-1}\), 44.25 leaf.plant\(^{-1}\), 1.775 cm\(^2\), 74.18 g.plant\(^{-1}\), 8.28 g.plant\(^{-1}\) and 55.11 SPAD respectively, while treatment Phe 200 mg.L\(^{-1}\)× NAA 100 mg.L\(^{-1}\) gave high value on plant height reached 81.02 cm compared with control which reached 55.63 cm.

The amino acid impact of Phe on growth parameters can be explained by increase in proteins content [26] and activating gibberellic acid biosynthesis [10], which lead to increase the growth rate by increase cell division, elongation, differentiation and consequently increase fresh and dry weight [27], amount of chlorophyll, leaf area and effective age of leaves[28], while the NAA is one of synthetic compounds which gave same auxins effects at exogenous spraying on plants, Auxins play key role in vascular tissue, differentiation, root initiation, apical dormancy, leaf senescence and leaf abscission[29].

Table 1. Effect of Phenylalanine (Phe), Naphthalene Acetic Acid (NAA) and their interactions on growth parameters, plant height (PH), branch number (BN), total leaf number (TLN), leaf area index (LAI), fresh weight (FW), dry weight (DW) and total chlorophyll (TCh).

| Treatments     | PH (cm) | BN (plant) | TLN (plant) | LAI (cm\(^2\)) | FW (g.plant\(^{-1}\)) | DW (g.plant\(^{-1}\)) | TCh (SPAD) |
|----------------|---------|------------|-------------|-----------------|-----------------------|-----------------------|-------------|
| Phe\(^0\)      | 59.94   | 5.21       | 48.73       | 1.950           | 81.92                 | 9.06                  | 55.56       |
| Phe\(^100\)    | 60.45   | 6.23       | 50.31       | 2.038           | 88.91                 | 9.82                  | 56.21       |
| Phe\(^200\)    | 72.59   | 6.34       | 54.13       | 2.180           | 92.45                 | 10.21                 | 56.93       |
| LSD (0.05)     | 2.36    | 0.19       | 0.88        | 0.035           | 0.63                  | 0.22                  | 0.06        |
| NAA\(^0\)      | 58.71   | 5.60       | 46.72       | 1.873           | 77.78                 | 8.64                  | 55.76       |
| NAA\(^50\)     | 64.34   | 6.29       | 56.69       | 2.283           | 96.48                 | 10.65                 | 56.74       |
| NAA\(^100\)    | 69.93   | 5.90       | 49.76       | 2.012           | 89.02                 | 9.79                  | 56.19       |
| LSD (0.05)     | 2.36    | 0.19       | 0.88        | 0.035           | 0.63                  | 0.22                  | 0.06        |
| Phe\(^0\)×NAA\(^0\) | 55.63   | 5.06       | 44.25       | 1.775           | 74.18                 | 8.28                  | 55.11       |
| Phe\(^0\)×NAA\(^50\) | 60.31   | 5.33       | 54.51       | 2.185           | 91.22                 | 10.04                 | 55.95       |
| Phe\(^0\)×NAA\(^100\) | 63.89   | 5.24       | 47.44       | 1.891           | 80.36                 | 8.85                  | 55.63       |
| Phe\(^200\)×NAA\(^0\) | 56.71   | 5.81       | 46.58       | 1.866           | 78.91                 | 8.69                  | 55.77       |
| Phe\(^200\)×NAA\(^50\) | 59.75   | 6.68       | 55.39       | 2.256           | 97.88                 | 10.89                 | 56.68       |
| Phe\(^200\)×NAA\(^100\) | 64.88   | 6.21       | 48.96       | 1.991           | 89.93                 | 9.88                  | 56.17       |
| Phe\(^200\)×NAA\(^0\) | 63.78   | 5.92       | 49.33       | 1.977           | 80.26                 | 8.94                  | 56.41       |
| Phe\(^200\)×NAA\(^50\) | 72.96   | 6.86       | 60.18       | 2.409           | 100.33                | 11.03                 | 57.59       |
| Phe\(^200\)×NAA\(^100\) | 81.02   | 6.24       | 52.88       | 2.154           | 96.77                 | 10.65                 | 56.78       |
| LSD (0.05)     | 4.67    | 0.38       | 1.55        | 0.075           | 1.11                  | 0.42                  | 0.15        |

3.2. Crop yield Components

Data presented in Table 2 show that the Phe concentration at 200 ml.L\(^{-1}\) gave significant effects (P≤0.05) on amounts of pod number, pod length, weight of 500 seeds, seed yield, Fresh leaves productivity, straw productivity and seed productivity, which resulted 36.38 pod.plant\(^{-1}\), 16.46 cm.pod\(^{-1}\), 13.52 g, 1.455, 0.467 Kg.m\(^{-2}\), 0.169 kg.m\(^{-2}\) and 36.387 kg.m\(^{-2}\) respectively, compared with control which gave 33.46 pod.plant\(^{-1}\), 15.23 cm.pod\(^{-1}\), 13.39 g, 1.389 kg.m\(^{-1}\), 0.156 kg.m\(^{-2}\) and 33.467 kg.m\(^{-2}\) respectively. Also table 2 shows that NAA concentration at 50 ml.L\(^{-1}\) gave the heights values on yield components, which
resulted 37.19 pod.plant$^{-1}$, 16.15 cm.pod$^{-1}$, 13.49 g, 1.518 g.plant$^{-1}$, 0.475 kg.m$^{-2}$, 0.175 Kg.m$^{-2}$ and 37.19 kg.m$^{-2}$ respectively, compared with control which gave 32.27 pod.plant$^{-1}$, 15.87 cm.pod$^{-1}$, 13.42 g, 1.316 g.plant$^{-1}$, 0.405 kg.m$^{-2}$, 0.151 kg.m$^{-2}$ and 32.27 kg.m$^{-2}$ respectively. The interaction treatment Phe 200 mL$^{-1}$ × NAA 50 mL$^{-1}$ gave the heights values on yield components, which resulted 38.42 pod.plant$^{-1}$, 16.43 cm.pod$^{-1}$, 13.57 g, 1.56 g.plant$^{-1}$, 0.497 kg.m$^{-2}$, 0.181 Kg.m$^{-2}$ and 38.42 kg.m$^{-2}$ respectively, compared with control which gave 31.01 pod.plant$^{-1}$, 14.81 cm.pod$^{-1}$, 13.36 g, 1.311 g.plant$^{-1}$, 0.384 kg.m$^{-2}$, 0.145 kg.m$^{-2}$ and 31.01 kg.m$^{-2}$ respectively.

The role of Phe on growth rate was led to increase accumulated dry weight on plants and increase amount of gibberellin biosynthesis which stimulated the flowering process and decrease abortion of flowers and finally lead to increase of yield components [10]. Whereas the NAA play an important role on cell elongation, division, differentiation, leaf abscission, fruit setting and flowering [19], finally NAA increased the productivity by increasing fresh and dry weight of pods and seeds.

Table 2. Effect of Phenylalanine (Phe), Naphthalene Acetic Acid (NAA) and their interactions on yield parameters pod number (PN), pod length (LP), seed number (SN), weight of 500 seeds (W 500 S), seed yield (SY), Fresh leaves productivity (FLP), straw productivity (STP) and seed productivity (SP).

| Treatments    | PN (pod. plant$^{-1}$) | LP (cm. pod$^{-1}$) | SN (seed. pod$^{-1}$) | W 500 S (g) | SY (g. plant$^{-1}$) | FLP (kg.m$^{-2}$) | STP (kg.m$^{-2}$) | SP (kg.m$^{-2}$) |
|---------------|-------------------------|---------------------|-----------------------|-------------|----------------------|------------------|------------------|------------------|
| Phe0          | 33.46                   | 15.23               | 10.86                 | 13.39       | 1.389                | 0.419            | 0.156            | 33.467           |
| Phe100        | 35.10                   | 16.44               | 10.87                 | 13.45       | 1.429                | 0.443            | 0.165            | 35.107           |
| Phe200        | 36.38                   | 16.46               | 10.86                 | 13.52       | 1.455                | 0.467            | 0.169            | 36.387           |
| LSD (0.05)    | 0.35                    | 0.21                | n.s                   | 0.07        | 0.056                | 0.021            | 0.011            | 0.355            |
| NAA0          | 32.27                   | 15.87               | 10.85                 | 13.42       | 1.316                | 0.405            | 0.151            | 32.27            |
| NAA50         | 37.19                   | 16.15               | 10.88                 | 13.49       | 1.518                | 0.475            | 0.175            | 37.19            |
| NAA100        | 35.50                   | 16.12               | 10.86                 | 13.45       | 1.437                | 0.450            | 0.164            | 35.50            |
| LSD (0.05)    | 0.355                   | 0.21                | n.s                   | 0.07        | 0.056                | 0.021            | 0.011            | 0.355            |
| Phe0×NAA0     | 31.01                   | 14.81               | 10.87                 | 13.36       | 1.311                | 0.384            | 0.145            | 31.01            |
| Phe100×NAA0   | 36.25                   | 15.55               | 10.87                 | 13.42       | 1.469                | 0.458            | 0.171            | 36.25            |
| Phe200×NAA0   | 33.14                   | 15.33               | 10.83                 | 13.39       | 1.387                | 0.414            | 0.152            | 33.14            |
| Phe0×NAA50    | 32.58                   | 16.45               | 10.85                 | 13.44       | 1.321                | 0.408            | 0.154            | 32.58            |
| Phe100×NAA50  | 36.91                   | 16.46               | 10.89                 | 13.47       | 1.527                | 0.469            | 0.174            | 36.91            |
| Phe200×NAA50  | 35.83                   | 16.41               | 10.88                 | 13.45       | 1.439                | 0.452            | 0.168            | 35.83            |
| Phe0×NAA100   | 33.22                   | 16.35               | 10.83                 | 13.47       | 1.318                | 0.422            | 0.154            | 33.22            |
| Phe100×NAA100 | 38.42                   | 16.43               | 10.89                 | 13.57       | 1.56                 | 0.497            | 0.181            | 38.42            |
| Phe200×NAA100 | 37.52                   | 16.61               | 10.86                 | 13.52       | 1.486                | 0.483            | 0.173            | 37.52            |
| LSD (0.05)    | 0.633                   | 0.45                | n.s                   | 0.17        | 0.097                | 0.082            | 0.024            | 0.633            |

3.3. Antioxidant Activity Parameters

The assessment of antioxidant activity of fenugreek in table 3 shows that Phe at concentration 200 mg.L$^{-1}$ effects on total phenolics content, total antioxidant capacity ferric reducing antioxidant power and radical scavenging activity, which reached to be 152.43, 49.03, 42.38, 53.47, 1.18, 0.38 7 mg.100g$^{-1}$ DW and 71.97, 77.42% in leaves and seeds respectively, compared with control which gave 113.73, 25.05, 40.20, 45.29, 0.887, 0.195 mg.100g$^{-1}$ DW and 68.27, 72.68% in leaves and seeds respectively. The NAA at concentration 100 mg.L$^{-1}$ gave the highest values on antioxidant activity parameters, which were 148.05, 49.21, 54.17, 1.155, 0.384 mg.100g$^{-1}$ DW and 76.77, 80.56% leaves and seeds respectively, compared with control treatment which gave 125.97, 19.81, 37.35, 42.92, 0.983, 0.155 mg.100g$^{-1}$ DW and...
63.42, 69.01% leaves and seeds respectively. The interaction Phe 200 mg.L\(^{-1}\) × NAA 100 mg.L\(^{-1}\) gave the highest values on antioxidant activity parameters, which reached to be 166.39, 64.57, 46.34, 58.96, 1.298, 0.504 mg.100g\(^{-1}\) DW and 78.69, 83.26% leaves and seeds respectively, compared with control which gave 105.01, 15.22, 33.70, 39.65, 0.819, 0.119 mg.100g \(^{-1}\) DW and 57.22, 67.33% in leaves and seeds respectively. T test showed significant superiority (P ≤0.05) for leaves to seeds on total phenolics content and ferric reducing antioxidant power, but seeds gave best value on radical scavenging activity compared with of seeds, but there are no significant between leaves and seeds on radical scavenging activity.

Table 3: Effect of Phenylalanine (Phe), Naphthalene Acetic Acid (NAA) and their interactions on Antioxidant Activity parameters total phenolics content (TPC), total antioxidant capacity (TAC), ferric reducing antioxidant power (FRAP) and radical scavenging activity (DPPH).

| Treatments         | TPC (mg.100g\(^{-1}\) DW) | TAC | FRAP | DPPH (%) |
|--------------------|---------------------------|-----|------|----------|
|                    | Leaves | Seeds | Leaves | Seeds | Leaves | Seeds |
| Phe\(^{0}\)        | 113.73 | 25.05 | 40.20  | 45.29  | 0.887  | 0.195 |
| Phe\(^{100}\)      | 145.41 | 35.59 | 42.33  | 48.60  | 1.134  | 0.278 |
| Phe\(^{200}\)      | 152.43 | 49.03 | 42.38  | 53.47  | 1.189  | 0.382 |
| LSD (0.05)         | 3.33   | 7.22  | 0.07   | 0.07   | 0.135  | 0.099 |
| NAA\(^{0}\)        | 125.97 | 19.81 | 37.35  | 42.92  | 0.983  | 0.155 |
| NAA\(^{50}\)       | 137.55 | 40.64 | 42.36  | 50.27  | 1.073  | 0.317 |
| NAA\(^{100}\)      | 148.05 | 49.23 | 45.21  | 54.17  | 1.155  | 0.384 |
| LSD (0.05)         | 3.33   | 7.22  | 0.07   | 0.07   | 0.135  | 0.099 |
| Phe\(^{0}\)×NAA\(^{0}\) | 105.01 | 15.22 | 33.70  | 39.65  | 0.819  | 0.119 |
| Phe\(^{0}\)×NAA\(^{50}\) | 116.05 | 25.36 | 42.07  | 46.38  | 0.905  | 0.198 |
| Phe\(^{0}\)×NAA\(^{100}\) | 120.14 | 34.58 | 44.84  | 49.86  | 0.937  | 0.270 |
| NAA\(^{0}\) × NAA\(^{0}\) | 133.26 | 18.57 | 39.51  | 43.56  | 1.039  | 0.145 |
| NAA\(^{0}\) × NAA\(^{50}\) | 145.36 | 39.67 | 43.04  | 48.56  | 1.134  | 0.309 |
| NAA\(^{0}\) × NAA\(^{100}\) | 157.61 | 48.55 | 44.44  | 53.69  | 1.229  | 0.379 |
| LSD (0.05)         | 3.33   | 7.22  | 0.07   | 0.07   | 0.135  | 0.099 |
| Phe\(^{100}\)×NAA\(^{0}\) | 116.05 | 25.36 | 42.07  | 46.38  | 0.905  | 0.198 |
| Phe\(^{100}\)×NAA\(^{50}\) | 139.65 | 25.64 | 38.84  | 45.57  | 1.089  | 0.200 |
| Phe\(^{100}\)×NAA\(^{100}\) | 151.24 | 56.89 | 41.96  | 55.89  | 1.180  | 0.444 |
| LSD (0.05)         | 6.32   | 15.02 | 0.14   | 0.15   | 0.271  | 0.011 |
| T test (0.05)      | 137.19a| 36.56c| 41.64c | 49.12c | 1.07a  | 0.29b |

Phe is basic substance of the phenylpropanoide path leading to the formation of phenolic compounds, flavonoids, tannins, coumarone and anthocyanin. The amino acids phenylalanine and tyrosine derived from the Shikimic acid pathway are the most common origin of polyphenols [30, 31], so adding amino acids increased the biosynthesis of polyphenols, which consist of flavonoids and phenolic acids that account for 60 and 30%, respectively of the total dietary polyphenols [32]. all these compound have antioxidant activity and Phe has been used to increase the production of this secondary compounds successfully [12]. NAA is a chemical industrial compound and sprayed this compound on plants maybe stimulate the abiotic stress mechanism and increasing production of antioxidant compounds. These results agreed with which mentioned that plant growth hormone are generally involved in growth and development especially under abiotic stress.
4. Conclusions
The spraying of Phe and NAA resulted significant increased on yield and antioxidant activity of the fenugreek, the treatments Phe 200 ml.L-1 × NAA 50 ml.L-1 and Phe 200 ml.L-1 × NAA 100 ml.L-1 induced the greatest increase in yield and antioxidant activity of fenugreek, these treatments could be used to improve the yield and quality of this active part of fenugreek plant in leaves or seeds, and increase dependent on medicated by medicinal plants.

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