Effects of Different Nitrogen Fertilization Rates and Foliar Application of Humic Acid, Fulvic Acid and Tryptophan on Growth, Productivity and Chemical Composition of Common Bean Plants (*Phaseolus vulgaris* L.)

Hasaan A. Elkhatib\(^1\), Said M. Gabr\(^1\), Alaa H. Roshdy\(^1\) and Radi S. Kasi\(^2\)

**ABSTRACT**

Two field experiments were carried out during the two successive seasons of 2015 and 2016 in a newly reclaimed private farm at Abu El-Matamor region, El-Beheira Governorate. The objective of this investigation was to study the main effects of four N-fertilizer levels (0, 20, 40, 60 kg N fad\(^{-1}\)) in the form of ammonium nitrate (33%) and three different stimulator treatments; humic acid (1 and 2 gmL\(^{-1}\)) fulvic acid (2.5 and 5 gmL\(^{-1}\)) and tryptophan (0.5 and 1 gmL\(^{-1}\)), as well as their interactions on vegetative growth, leaf chlorophyll, N, P and K contents and yield and its components characters of common bean cv. Nebraska. The obtained results indicated that application of mineral N, significantly increased all the studied growth, minerals and yield characters. The highest N rates (60 kg N fad\(^{-1}\)) was remarkable and associated with the highest mean values of the most studied characters. Moreover, the biostimulator treatments application exhibited higher mean values of all studied growth, minerals and yield parameters compared to control. Tryptophan treatment was more pronounced in this concern. It could conclude that fertilization of common bean plants with 60 kg N fad\(^{-1}\) combined with tryptophan at 1 gmL\(^{-1}\) was the best interaction treatment for all the studied parameters.

Keywords: common bean, nitrogen fertilization, humic acid, fulvic acid, tryptophan.

**INTRODUCTION**

Common bean is one of the most ancient crops. It is the most important grain legume for direct human consumption in the world. The crop is consumed principally as dry (mature) beans (Gepts, 2001).

Common bean (*Phaseolus vulgaris* L.) is one of the most important vegetable crops in Egypt. The total cultivated area of dry beans was 39665 ha with a production of 98132 metric tons (FAOSTAT, 2017). Nutritionists characterized the common bean as a nearly perfect food because it represents an inexpensive source of protein (22-37%) and micronutrients to low-income consumers, where each harvested hectare dry beans would yield up to 125 kg of protein. In contrast, only 3.4 kg of protein were produced by livestock on the same area of land, during the time it takes a bean crop to reach maturity (Bazzano et al., 2001). Also, common bean is an important source of energy. Beans also provide substantial quantities of amino acids, dietary fibers, minerals (Ca, P, Fe, K, Mg and Mn) and vitamins (A, B1, B2 and C) (Bekaert et al., 2008; Hefni et al., 2010). The inclusion of bean in diets is linked to numerous health benefits such as the reduction of coronary heart diseases and cholesterol level (Bazzano et al., 2001).

Importance of nitrogen role in physiological and biochemical processes is well known for plants (Fageria, 2016). Many investigators reported that N fertilization application improved the plant growth, yield and its components, and chemical composition of common bean (Almeida et al., 2016; Buetow et al., 2017; Soratto et al., 2017). Under the intensive agricultural systems, the excessive use of mineral nitrogen fertilizers was found to cause serious environmental problems with soil fertility, human health, food security and air pollution (Ju et al., 2009; Tilman et al., 2011; Gregorich et al., 2015). On the other hand, Tilman et al. (2002) announced that the global use of nitrogen fertilizers increased by 7-fold in the past six decades. Nitrogen fertilizer use is expected to increase threefold by 2050. Therefore, introducing new approaches to overcoming such problems is necessary.

The positive effect of organic amendments or plant bio stimulants based on humic substances is an alternative method for improvement of crop production and soil fertility maintenance (Canellas et al., 2015). The application of humic acid HA has indirect and direct beneficial effects; the indirect effects by improving soil aggregation, structure, fertility, and moisture holding capacity, and increasing microbial activity (Chen and Aviad, 1990; Sharif, 2002), microbial population, and cation exchange capacity (Marinari et al., 2000). The direct beneficial effects of HA on plant growth and development where it affects cell membranes which lead to the enhanced transport of minerals, improved protein synthesis, promoted photosynthesis, modified enzyme activities, solubility of micro and macro-elements, reduction of active levels of

---

**DOI:** 10.21608/ASEJAIQISAE.2020.93900

\(^1\)Department of Horticulture, Faculty of Agriculture, Damanhour University.

\(^2\)Ministry of Agriculture and Land Reclamation.

Received March 09, 2020, Accepted, June 2, 2020.
toxic minerals (Selim et al., 2009). Furthermore, HA is considered as plant hormone-like substance (Canellas et al., 2015; Scaglia et al., 2016). There were many investigations stated the beneficial effect of HA on growth and yield of different crop plants (El-Bassiony et al., 2010 on snap bean and Omar, 2013 on broad bean).

Fulvic acid (FA) is the second important humus substance, which is considered a good bio-stimulant for better plant growth and yield (Canellas et al., 2015). Fulvic acid as an organic fertilizer, is a non-toxic mineral chelating additive and water binder that maximizes uptake through leaves and stimulates plant productivity (Malan, 2015). It attracts water molecules, helping the soil to remain moist and aiding the movement of nutrients into plant roots. Fulvic acid easily binds or chelates minerals such as iron, calcium, copper, zinc and magnesium, as it can deliver these elements to plant directly (Yamauchi et al., 1984). In many studies, other effects of fulvic acid application were reported such as; enhancing root growth and maximize the produced yield of cucumber plants (Kamel et al., 2014) also promoting plant growth and increasing the marketable yield in tomato production (Suh et al., 2014).

Tryptophan (Trp) is common precursor of plant hormone (auxin). Tryptophan is well known as a physiological precursor of indole acetic acid and its application at appropriate concentrations could have a positive effect on plant growth because of slow and gradually continuous release of indole acetic acid from tryptophan (Zahir et al., 2000). Tryptophan may act as an osmolyte, ion transport regulator, modulates stomatal opening and its pathway plays a defensive role in plants (Hussein et al., 2014). The exogenous application of Trp was found to be effective in enhancing the performances of the treated plants (Dawood and Sadak, 2007 on canola; Abbas et al., 2013, on chickpea; Mustafa et al., 2016 on okra; Frankenberger et al., 1990 on radish and Frankenberger and Arshad, 1991 on watermelon and muskmelon). The effects of Trp on the growth and yield could be attributed directly to the uptake by plant roots with subsequent catabolism into auxins with the plant tissue; indirectly to auxin metabolites produced by the rhizosphere micro flora which were subsequently taken up by plant roots; alteration in the balance of rhizosphere microbial community in response to Trp addition, which may affect growth and yield (Frankenberger and Arshad, 1995)

The present study was conducted to investigate the response of common bean plants to foliar spray with humic acid, fulvic acid, and tryptophan under different levels of nitrogen fertilizer on vegetative growth, yield and chemical contents of common bean.

MATERIALS AND METHODS

Two field experiments were carried out at a newly reclaimed private farm at Abu El-Matamer region, El-Beheira Governorate. The soil was cultivated with bean plants (Phaseolus vulgaris L.) cv Nebraska secured from the Egyptian Agriculture Research Center, Ministry of Agric., A.R.E. Bean seeds sown on 23rd of September, 2015 and 30th of September, 2016.

Soil analysis

Prior to conduct of the experiments Soil surface samples (0-25 cm) were taken and then air dried, ground, sieved through a 2 mm sieve and then the important physical and chemical characteristics of the experimental site (Table 1) were determined according to the methods reported by Page et al. (1982).

Table 1. Physical and chemical characteristics of the soil used in the experimental site in 2015 and 2016 seasons

| * Physical analysis | First season | Second season |
|---------------------|--------------|--------------|
| Sand                | 89%          | 89%          |
| Clay                | 6%           | 6%           |
| Silt                | 5%           | 5%           |
| Soil texture        | sand         | sand         |
| * Chemical analysis | First season | Second season |
| pH                  | 8.1          | 8.2          |
| EC (dSm⁻¹)          | 1.4          | 1.6          |
| CaCO3 (%)           | 3.10         | 2.98         |

| Elements (ppm)     |               |               |
| N                   | 27            | 35            |
| P                   | 17            | 21            |
| K                   | 178           | 170           |

* These analyses were carried out at the Soil Reclamation and Agric. Engineering Dept., Agric. Fac., Damanhour University.

Experimental Layout

The experimental design was split plot system in a randomized complete block design with four replicates. Mineral nitrogen fertilizer levels (0, 20, 40 and 60 kg N fad⁻¹ in the form of ammonium nitrate (33%) were the main plots whereas, the stimulators; humic acid (HA) (1 and 2 gL⁻¹), fulvic acid (FA) (2.5 and 5 gL⁻¹), tryptophan (Trp) (0.5 and 1 gL⁻¹) and control treatment were distributed in the sub-plots.

The nitrogen fertilization treatments were applied by hand at two equal doses; 3 and 6 weeks after sowing. Also, the foliar spray of the stimulators was applied in two equal doses; at 24 days after sowing, and the beginning of the blooming stage. The plots were formed by 7 rows, which were 6 m long and 0.5 m width for each. The seeds were sowed at 12 cm apart in both sides.
of each row, that the faddan contains 70 thousand plants.

Phosphorus and potassium fertilizations were applied in doses of 48 kg P fad\(^{-1}\) and 60 kg K fad\(^{-1}\) in the form of calcium super phosphate (15% \(P_2O_5\)) and potassium sulphate (48% \(K_2O\)), respectively. All other agricultural practices were applied according to the recommendations for common bean commercial production.

**Experimental Data:**

The data of vegetative growth characters were recorded using five random chosen plants from each treatment, 60 days after seed sowing. The following measurements were recorded: plant height (cm), foliage fresh weight (g), foliage dry weight (g), number of leaves plant\(^{-1}\) and leaves area plant\(^{-1}\) (cm\(^2\)).

The collected plant samples were washed with tap water, distilled water, then oven dried at 70 °C for 48 hours and ground in a mill with stainless steel blades. Wet digestion was performed according to the procedure described by Chapman and Pratt (1978) and the following determinations were carried out in the digested solution. Nitrogen percentage (N%) in leaves was determined by micro kjeldahl method according to (Page et al. 1982). Phosphorus (P%) was determined colorimetrically, while, potassium (K%) was determined by flame photometer as illustrated by (Temminghoff and Houba, 2004). Whereas, the yield and its components characters were recorded at harvest time as number of pod plant\(^{-1}\), pods weight plant\(^{-1}\), seed yield plant\(^{-1}\) (g), and seeds yield fad\(^{-1}\).

**Statistical Analysis:**

All obtained records were statistically analyzed by using CoStat program (Version 6.4, Co Hort., USA, 1998–2008). Least significant difference test (LSD) was applied at 0.05 confidence level to compare the different treatments means by using the same program.

**RESULTS AND DISCUSSION**

1. **Vegetative growth characters:**

1.1. **Effect of Nitrogen fertilizer**

The main effect of nitrogen doses on plant height, foliage fresh weight, foliage dry weight and leaves area plant\(^{-1}\) of common bean plants in 2015 and 2016 seasons are given in Tables (2-5).

Generally, the results revealed that nitrogen application rates had significant effects on plant height, foliage fresh weight, foliage dry weight and leaves area plant\(^{-1}\) of common bean plants in the two growing seasons compared to the control treatment. Also, adding 60 kg N fad\(^{-1}\) gave the highest mean values of common bean vegetative growth characters. The average increment percentages of the two seasons of study were estimated by 22.67% for plant height, 96.80% for foliage fresh weight, 94.66% for foliage dry weight, and 85.04% for leaves area plant\(^{-1}\) compared to control treatment. The vital role of nitrogen fertilization is well discussed by many authors. They stated the vital role of nitrogen in enhancing the plants content of amino acids (Losak et al., 2010; Kandi et al., 2012), regulating the production of phytohormones (Pavlíková et al., 2012). Nitrogen is essential for co-enzymes, photosynthetic pigments, secondary metabolites and stimulate polyamine synthesis (Maathuis, 2009; Leghari et al., 2016). Similar results were reported by several researchers clarified the importance of nitrogen fertilization for enhancing the vegetative growth characters of the vegetable crops such as Gabr et al. (2007) on pea, El-khatib (2009) on bean and Hegazi et al. (2010) on common bean. El-Awadi et al. (2011) found that the using of 100% of recommended dose of N fertilization on bean plants, significantly, increased the vegetative growth criteria (i.e. plant length, leaves number plant\(^{-1}\), number of branches plant\(^{-1}\) and fresh and dry weight of leaves plant\(^{-1}\) compared to the lower levels.

1.2. **Effect of stimulative treatments**

Foliar applications of HA, FA and Trp revealed significant increments in plant height, foliage fresh and dry weight and leaves area over the control treatment, in both seasons (Tables 2-5). In general, Trp2 treatment was caused best growth performance followed by FA treatments, in both seasons of study. The average increment percentages of two seasons of the vegetative growth characters due to Trp1 treatment were 7.01% for plant height, 20% for foliage fresh weight, 19.35% for foliage dry weight, 19.05% for number of leaves plant\(^{-1}\) and 23.56% for leaves area over the control. Meanwhile, the average increment percentages of two seasons of the vegetative growth characters due to Trp2 treatment were 6.18% for plant height, 22.48% for foliage fresh weight, 20.53% for foliage dry weight, 22.04% for number of leaves plant\(^{-1}\) and 27.76% for leaves area over the control treatment.

The current results are in agreement with the results reported by many investigators illustrated the beneficial effect of tryptophan in increasing the mean values of the vegetative growth characteristics of many of crop plants could be attributed to either: (a) auxin metabolites produced by the rhizosphere flora which were subsequently taken up by plant roots, or, (b) direct uptake by plant roots with subsequent catabolism into auxins with the plant tissue or (c) alteration in the balance of rhizosphere microbial community in response to Trp addition, which may affect growth (Zahir et al., 2010 on mung bean, El-Awadi et al., 2011 on snap bean and Abbas et al., 2013 on chickpea).
1.3. The effects of interactions

Concerning the effects of interactions between stimulation compounds and nitrogen fertilizer levels on the vegetative growth characters of bean plants, the obtained results of the two seasons revealed that the addition of 60 kg N fad⁻¹ and Trp2 treatment was pronounced and aided in attainment the best vegetative growth. The increments of foliage dry weight and leaves area plant⁻¹ estimated by 17.66 and 20.85% respectively as an average percentage of the two seasons compared to control treatments. These results are in consistency to those of Zahir et al. (2010), who determined significant increase in plant biomass of mung bean with different Trp concentrations.

Table 2. The main effects of nitrogen levels, stimulative treatments and their interactions on plant height, foliage fresh weight and foliage dry weight of common bean during 2015 season

| Stimulative treatments | Nitrogen levels (kg fad⁻¹) | Plant height (cm) | Foliage fresh weight (g) | Foliage dry weight (g) |
|------------------------|----------------------------|-------------------|--------------------------|------------------------|
|                        | 0  | 20  | 40  | 60  | Mean | 0  | 20  | 40  | 60  | Mean | 0  | 20  | 40  | 60  | Mean |
| Control                |    |     |     |     |      | 35.33f | 42.56b-e | 43.22a-e | 44.57a-d | 41.42B |
| AH1                    |    |     |     |     |      | 36.22f | 43.57a-d | 46.78ab | 42.78AB |
| AH2                    |    |     |     |     |      | 35.11f | 44.55a-d | 47.00ab | 43.22AB |
| FA1                    |    |     |     |     |      | 39.11d-f | 43.10a-e | 45.78a-c | 47.00ab | 43.75AB |
| FA2                    |    |     |     |     |      | 37.00ef | 43.53a-d | 46.89ab | 43.13AB |
| Trp1                   |    |     |     |     |      | 39.89c-f | 43.34a-d | 49.11a-c | 44.61A |
| Trp2                   |    |     |     |     |      | 39.22d-f | 44.89a-d | 47.22ab | 44.33AB |
| Mean                   |    |     |     |     |      | 37.41C | 43.65B | 45.29B | 46.94A |

* The mean values with the same alphabetical letters do not differ significantly at 0.05% probability level.
Table 3. The main effects of nitrogen levels, Stimulative treatments and their interactions on number of leaves plant\(^1\) and leaves area of common bean cv. Nebraska, during 2015 season

| Stimulative treatments | 0       | 20      | 40       | 60       | Mean    |
|------------------------|---------|---------|----------|----------|---------|
| Control                | 9.33i-n | 12.33i-n| 15.66j   | 17.11d-g | 13.61C  |
| AH1                    | 8.88mn  | 14.44f-k| 19.33b-e | 19.00b-f | 15.41A-C|
| AH2                    | 9.77k-n | 13.22g-m| 16.88e-i | 19.33b-e | 14.81BC |
| FA1                    | 8.44n   | 14.00g-l | 17.77c-g | 22.44a-c | 15.66A-C|
| FA2                    | 8.88mn  | 14.44f-k| 17.33d-g | 23.55ab  | 16.05AB |
| Trp1                   | 11.55j-n| 13.11g-n| 17.22d-h | 21.77a-d | 15.91A-C|
| Trp2                   | 12.55h-n| 14.22g-k| 17.55d-g | 26.00a   | 17.58A  |
| Mean                   | 9.92D   | 13.68C  | 17.39B   | 21.31A   |         |

| Leaves area (cm\(^2\)) |    |         |         |         |         |         |
|-------------------------|----|---------|---------|---------|---------|---------|
| Control                 | 677.54h | 869.83h | 1255.73d | 1385.89cd | 1047.25D |
| AH1                     | 758.25gh| 1030.23e-g| 1226.99d-e | 1429.88b-d | 1111.34CD |
| AH2                     | 833.84gh| 1038.48e-g| 1375.79c-d | 1640.50a-c | 1222.15BC |
| FA1                     | 718.39h | 1150.01d-f | 1623.10a-c | 1748.21a   | 1309.93AB |
| FA2                     | 753.83gh| 1232.54d-e | 1750.08a   | 1789.98a   | 1381.61A |
| Trp1                    | 820.46gh| 1224.08d-e | 1715.59ab  | 1629.65a-c | 1347.44AB |
| Trp2                    | 888.49f-h| 1241.95d-e | 1867.34a   | 1777.19a   | 1443.74A |
| Mean                    | 778.69C | 1112.44B | 1544.95A  | 1628.75A   |         |

* The mean values with the same alphabetical letters do not differ significantly at 0.05% probability level.

Table 4. The main effects of nitrogen levels, Stimulative treatments and their interactions on plant height, foliage fresh weight and foliage dry weight of common bean cv. Nebraska, during 2016 season

| Stimulative treatments | 0       | 20      | 40       | 60       | Mean    |
|------------------------|---------|---------|----------|----------|---------|
| Control                | 36.89k  | 41.11f-g | 42.44c-h | 45.11a-d | 41.38B  |
| AH1                    | 38.33jk | 43.78a-f | 43.11c-g | 45.55a-c | 42.69AB |
| AH2                    | 36.77k  | 41.88i-e | 44.77a-e | 46.55a   | 42.49AB |
| FA1                    | 39.77h-k| 42.00d-i | 45.44a-c | 46.55a   | 43.44A  |
| FA2                    | 40.44g-j| 41.55f-i | 45.55a-c | 46.33ab  | 43.47A  |
| Trp1                   | 38.91i-k| 45.22a-c | 45.33a-c | 46.55a   | 44.00A  |
| Trp2                   | 39.89h-k| 43.33b-g | 44.78a-e | 46.33ab  | 43.58A  |
| Mean                   | 38.71C  | 42.69B  | 44.49AB  | 46.14A   |         |

| Foliage fresh weight (g) |    |         |         |         |         |         |
|--------------------------|----|---------|---------|---------|---------|---------|
| Control                  | 32.48l | 49.80f-k | 58.55d-i | 64.87b-e | 51.43B  |
| AH1                      | 37.36kl| 48.93g-k | 55.13e-j | 85.45a   | 56.72AB |
| AH2                      | 46.17h-l| 61.29c-g | 63.95b-f | 72.26a-d | 60.92A  |
| FA1                      | 43.68i-l| 54.80e-j | 59.21d-h | 77.96ab  | 58.91AB |
| FA2                      | 43.77i-l| 54.72e-j | 65.47b-e | 84.29a   | 62.06A  |
| Trp1                     | 49.58f-k| 54.58e-j | 62.65c-g | 68.64b-e | 58.86AB |
| Trp2                     | 41.37j-l| 61.55c-g | 63.90b-f | 74.21a-c | 60.26AB |
| Mean                     | 42.06D | 55.10C  | 61.27B   | 75.38A   |         |

| Foliage dry weight (g)   |    |         |         |         |         |         |
|--------------------------|----|---------|---------|---------|---------|---------|
| Control                  | 5.24jk | 8.30f-i | 9.65c-h | 10.73a-f | 8.48C   |
| AH1                      | 5.37jk | 8.50e-i | 10.97a-e | 11.57a-d | 9.10BC  |
| AH2                      | 4.96k  | 9.47c-h | 12.00a-c | 12.41ab  | 9.71A-C |
| FA1                      | 6.00k  | 7.31h-k | 9.89b-g | 10.95a-e | 8.54C   |
| FA2                      | 7.48g-k| 7.58g-j | 11.54a-d | 12.02a-c | 9.65A-C |
| Trp1                     | 7.36g-k| 9.63c-h | 12.55a   | 12.50a   | 10.51A  |
| Trp2                     | 6.62i-k| 9.35d-h | 11.89a-d | 12.44ab  | 10.07AB |
| Mean                     | 6.15C  | 8.59B   | 11.21A   | 11.80A   |         |

* The mean values with the same alphabetical letters do not differ significantly at 0.05% probability level.
Table 5. The main effects of nitrogen levels, Stimulative treatments and their interactions on number of leaves plant\(^1\) and leaves area of common bean cv. Nebraska, during 2016 season

| Stimulative treatments | Nitrogen levels (kg fad\(^{-1}\)) | Number of leaves plant\(^1\) | Leaves area (cm\(^2\)) |
|-----------------------|-----------------------------------|-----------------------------|------------------------|
|                       | 0                                 | 20                          | 40                     | 60         | Mean     |
| Control               | 12.22c                            | 13.33c-e                    | 16.66a-e               | 16.55a-e | 14.69C   |
| AH1                   | 12.22e                            | 12.66de                     | 18.22ab                | 18.33ab  | 15.36BC  |
| AH2                   | 12.33e                            | 16.22a-e                    | 18.33ab                | 18.66a   | 16.38A-C |
| FA1                   | 15.78a-e                          | 14.11b-e                    | 18.33ab                | 18.89a   | 16.77A-C |
| FA2                   | 16.89a-d                          | 16.44a-e                    | 18.00ab                | 17.55a-c | 17.22AB  |
| Trp1                  | 17.78a-c                          | 18.88a                      | 17.44a-c               | 17.11a-d | 17.80A   |
| Trp2                  | 14.88a-e                          | 17.44a-c                    | 17.00a-d               | 18.22ab  | 16.88A-C |
| Mean                  | 14.58C                            | 15.58B                      | 17.71A                 | 17.90A   |          |

* The mean values with the same alphabetical letters do not differ significantly at 0.05% probability level.

2- Leaves chemical contents and chlorophyll

2.1- The Effect of Nitrogen fertilizer

The effect of nitrogen fertilizer levels and the stimulative compounds and their interactions on chlorophyll and leaves chemical contents of common bean plants were listed in Tables (6 and 7).

The recorded results of the effect of nitrogen levels on the various studied chemical contents of leaves of bean plants (Tables 6 and 7) clarified significant increments on leaves N, P, K and chlorophyll contents due to increasing N fertilizer from 20 to 60 Kg N fad\(^{-1}\) compared to the control treatment in both seasons of study. The application of 60 Kg N fad\(^{-1}\) seemed to be sufficient and pronounced in this concern. The average percentage increments of the two seasons due to Trp treatment for N, P and K content were 6.25, 8.78 and 6.95% respectively. On the other hand, HA treatment showed the highest mean value of chlorophyll content and the average increment percentage of the two seasons was (3.41%). The obtained results are in agreement with those of Dawood and Sadak (2007) who stated that the Trp foliar application increased the leaves N content significantly. Moreover, the enhancement effect of tryptophan was supported with the study of Rizwan et al. (2008) who reported that in the presence of tryptophan, significant increases in N, P and K contents (76.2, 54.6 and 63%, respectively) were observed over control. In addition, there were many investigations stated the significant beneficial effect of application of HA on the nutrient composition and chlorophyll content of the treated plants (Kalyoncu et al., 2017 on mung bean).

2.2- The effects of stimulative treatments:

The results revealed significant effect on leaves N, P, K and chlorophyll contents due to these treatments compared to the control treatment in both seasons of study, also the results showed that Trp treatment was the most pronounced and associated with the highest mean values of N, P, K content of leaves, in both seasons (Tables 6 and 7). The average percentage increments of the two seasons due to Trp treatment for N, P and K contents were 6.25, 8.78 and 6.95% respectively. On the other hand, HA treatment showed the highest mean value of chlorophyll content and the average increment percentage of the two seasons was (3.41%). The obtained results are in agreement with those of Dawood and Sadak (2007) who stated that the Trp application resulted in announced increase in leaves contents of photosynthetic pigments of canola plants. Also, Zahir et al. (2010) on mung bean revealed that the Trp foliar application increased the leaves N content significantly. Moreover, the enhancement effect of tryptophan was supported with the study of Rizwan et al. (2008) who reported that in the presence of tryptophan, significant increases in N, P and K contents (76.2, 54.6 and 63%, respectively) were observed over control. In addition, there were many investigations stated the significant beneficial effect of application of HA on the nutrient composition and chlorophyll content of the treated plants (Kalyoncu et al., 2017 on mung bean).
2.3- The effects of interactions

Concerning the interaction effects of stimulative treatments and nitrogen fertilizer levels on chemical contents of bean leaves (Tables 6 and 7), the obtained results clearly showed that the stimulative treatments accompanied with nitrogen fertilization at the rate of 60 Kg N fad\(^1\), significantly increased the mean values of N, P, K and chlorophyll contents, in both seasons, relative to the control treatment. Also, the results revealed that the highest nitrogen fertilization (60 Kg N fad\(^1\)) and Trp2 treatments, exhibited the highest mean values of N, P and K contents estimated by 11.17, 8.34 and 7.19% respectively, as the average increment percentages of the two seasons followed by Trp1 and FA2. Similar results were observed by Chen et al. (2005), who found that TRP improved N, P, K, and Zn uptake by maize plants. Also, Abou El-Yazied and Mady (2012) found that foliar application of boron (B) and yeast extract (containing Tryptophan) increased photosynthetic pigments, nitrogen, phosphorous, potassium, boron, total sugars, total free amino acids, and crude protein content in leaves of faba bean (Vicia faba L.).

Table 6. The main effects of nitrogen levels, stimulative treatments and their interactions on leaves N, P, K and chlorophyll contents of common bean during 2015 season

| Stimulative treatments | Nitrogen levels (kg fad\(^1\)) | 0  | 20 | 40 | 60 | Mean |
|------------------------|--------------------------------|----|----|----|----|------|
|                        | N%                            |    |    |    |    |      |
| Control                | 3.22I-n                        | 3.27j-n | 3.38h-m | 3.58d-h | 3.36C |
| AH1                   | 3.20mn                        | 3.31l-n | 3.40f-l | 3.73b-e | 3.41BC |
| AH2                   | 3.25k-n                       | 3.46f-k | 3.57e-h | 3.78b-d | 3.52A |
| FA1                   | 3.38h-m                       | 3.47f-j | 3.59c-g | 3.79a-c | 3.56A |
| FA2                   | 3.12n                         | 3.48f-i | 3.50f-i | 3.84ab  | 3.48AB|
| Trp1                  | 3.39g-m                       | 3.48f-i | 3.54e-h | 3.59c-g | 3.50AB|
| Trp2                  | 3.23I-n                       | 3.61c-f | 3.52f-h | 3.99a   | 3.59A |
| Mean                  | 3.26C                         | 3.44B  | 3.50B  | 3.76A  |      |
|                        | P%                            |    |    |    |    |      |
| Control                | 0.42I-k                       | 0.427jk | 0.457h-j | 0.528b-d | 0.458D |
| AH1                   | 0.419k                        | 0.46i-k | 0.462g-i | 0.511c-f | 0.459D |
| AH2                   | 0.421k                        | 0.44i-k | 0.479f-h | 0.509d-f | 0.463CD |
| FA1                   | 0.457h-j                      | 0.460h-j | 0.472g-i | 0.518c-e | 0.477BC |
| FA2                   | 0.378I                        | 0.470g-i | 0.493e-g | 0.543a-c | 0.471B-C |
| Trp1                  | 0.443i-k                      | 0.465g-i | 0.454h-j | 0.556ab  | 0.480B |
| Trp2                  | 0.460h-j                      | 0.470g-i | 0.481f-h | 0.573a   | 0.496A |
| Mean                  | 0.429C                        | 0.455B  | 0.471B  | 0.534A  |      |
|                        | K%                            |    |    |    |    |      |
| Control                | 2.380hi                       | 2.459f-i | 2.517e-h | 2.580c-f | 2.48DE |
| AH1                   | 2.427f-i                      | 2.383hi | 2.442f-i | 2.594b-f | 2.46E |
| AH2                   | 2.386g-i                      | 2.597b-f | 2.699f-i | 2.770ab  | 2.61AB|
| FA1                   | 2.475f-i                      | 2.537d-h | 2.515f-h | 2.692a-e | 2.55B-D |
| FA2                   | 2.328i                        | 2.499f-i | 2.551d-h | 2.708a-d | 2.52C-E|
| Trp1                  | 2.549d-h                      | 2.467f-i | 2.562c-g | 2.730a-c | 2.58A-C|
| Trp2                  | 2.549d-h                      | 2.584c-f | 2.707a-d | 2.773a   | 2.65A |
| Mean                  | 2.44C                         | 2.50C  | 2.57B  | 2.69A   |      |

Chlorophyll (SPAD)

|                |                  |      |      |      |      |      |
|----------------|------------------|------|------|------|------|
| Control        | 40.07c           | 40.71a-c | 40.27bc | 41.69a-c | 40.68B |
| AH1            | 40.63a-c         | 41.93a-c | 41.59a-c | 41.92a-c | 41.52AB|
| AH2            | 41.32a-c         | 41.89a-c | 41.76a-c | 42.32ab  | 41.82A |
| FA1            | 41.03a-c         | 41.05a-c | 41.50a-c | 42.39ab  | 41.49AB|
| FA2            | 41.70a-c         | 41.63a-c | 42.18a-c | 41.75a-c | 41.81A |
| Trp1           | 40.74a-c         | 41.28a-c | 42.10a-c | 41.88a-c | 41.50AB|
| Trp2           | 40.35bc          | 41.99a-c | 41.63a-c | 42.67a   | 41.66AB|
| Mean           | 40.83B           | 41.50AB | 41.57AB | 42.09A   |      |

* The mean values with the same alphabetical letters do not differ significantly at 0.05% probability level.
The application of 20, 40 and 60 Kg N gave the highest mean values of pods No. plant\(^{-1}\), seeds wt. plant\(^{-1}\) and seeds yield fad\(^{-1}\), followed by 40 Kg N fad\(^{-1}\), in both seasons. The highest nitrogen levels (60 Kg N fad\(^{-1}\)) appeared to be sufficient for the bean plants to express their best performances on the previously mentioned parameters. The estimated increments in yield and its components at the highest nitrogen levels (60 Kg N fad\(^{-1}\)) expressed as the average increment percentages of the two seasons compared to the control were 53.91% for pods number plant\(^{-1}\), 61.66% for pods weight plant\(^{-1}\),

3- Yield and its components:

3.1- The effect of nitrogen fertilizer

The effect of main factors of nitrogen fertilizer levels and the stimulative compounds and their interactions on yield and its components are listed in Tables (8 and 11). The application of 20, 40 and 60 Kg N fad\(^{-1}\), significantly increased pods No. plant\(^{-1}\), dry seeds yield plant\(^{-1}\) and yield fad\(^{-1}\) than the control treatment, in both seasons. The results showed that the addition of nitrogen fertilization at the rates of 60 kg N fad\(^{-1}\) gave the highest mean values of pods No. plant\(^{-1}\), seeds wt. plant\(^{-1}\) and seeds yield fad\(^{-1}\), followed by 40 Kg N fad\(^{-1}\), in both seasons. The highest nitrogen levels (60 Kg N fad\(^{-1}\)) appeared to be sufficient for the bean plants to express their best performances on the previously mentioned parameters. The estimated increments in yield and its components at the highest nitrogen levels (60 Kg N fad\(^{-1}\)) expressed as the average increment percentages of the two seasons compared to the control were 53.91% for pods number plant\(^{-1}\), 61.66% for pods weight plant\(^{-1}\),

Table 7. The main effects of nitrogen levels, stimulative treatments and their interactions on yield and its components are listed in

| Stimulative treatments | 0       | 20      | 40      | 60      | Mean   |
|------------------------|---------|---------|---------|---------|--------|
| Control                | 3.04l   | 3.20h-j | 3.17jk  | 3.40e   | 3.20D  |
| AH1                    | 3.07kl  | 3.23g-j | 3.21g-j | 3.68a-c | 3.30C  |
| AH2                    | 3.18i-k | 3.24g-j | 3.31e-g | 3.61cd  | 3.33A-C|
| FA1                    | 3.16jk  | 3.20h-j | 3.30e-h | 3.64bc  | 3.32BC |
| FA2                    | 3.15jk  | 3.28f-i | 3.28f-i | 3.74ab  | 3.36AB |
| Trp1                   | 3.15j-l | 3.20h-j | 3.31e-g | 3.52d   | 3.29C  |
| Trp2                   | 3.16jk  | 3.21g-j | 3.40ef  | 3.77a   | 3.38A  |
| Mean                   | 3.13D   | 3.22C   | 3.28B   | 3.62A   |        |

* The mean values with the same alphabetical letters do not differ significantly at 0.05% probability level.
61.49% for seeds yield plant\(^{-1}\) and 61.49% for seeds yield fad\(^{-1}\).

The increments of dry yield fad\(^{-1}\) as a result of nitrogen application might be attributed directly to the increased pods number plant\(^{-1}\) and/or might be attributed to the potentiality of nitrogen, particularly 60 Kg N fad\(^{-1}\) to assure the adequate and balanced nitrogen requirements, which favored optimum growth and, in turn achieved more seeds yield (Singh, 2000). The present results agreed to a great extent, with those reported by El-Awadi et al. (2011) who have shown that the application of nitrogen fertilizer at the rate of 100 Kg N fad\(^{-1}\) on bean plants, significantly, increased the yield of snap bean as well as its attributes as compared to control. Also, Reddy et al. (2010) reported that increased nitrogen levels from 75 to 150 kg ha\(^{-1}\) improved the yield attributes and seed yield and concluded that the increase in yield might be due to increased nitrogen availability, causing accelerated photosynthetic rate leading to more production of carbohydrates and improvement in growth and yield attributes.

3.2- The effects of stimulative treatments

In the case of the effect of stimulative treatments on yield and its components of common bean, the results reflected significant differences among all the different treatments compared to the control treatment on the yield and its components. Also, this trend was evident during the two seasons. Moreover, the results illustrated that Trp2 was the most pronounced treatment followed by Trp1 and FA2. The estimated increase in yield and its components; expressed as pods number plant\(^{-1}\), dry pods yield plant\(^{-1}\), and dry seeds yield plant\(^{-1}\) and seeds yield fad\(^{-1}\) as an average of the two seasons, due to Trp2 were 26.11, 26.1, 26.97, and 26.97% compared to the control treatment. On the other hand, the increments as an average of the two seasons for Trp1 were 20.31% for pods yield plant\(^{-1}\) and 18.21% for dry seeds yield plant\(^{-1}\) and 18.21% for seeds yield fad\(^{-1}\).

Many research papers were illustrated the beneficial effects of the Trp foliar application as a significant treatment for increasing yield and its components of the treated plants such as Dawood and Sadak (2007) on canola; El-Bassiony et al. (2010) on snap bean; El-Awadi et al. (2011) on snap bean.; Abbasi et al. (2013) on chickpea; Amin et al. (2014) on lupine.; Abd El-wahed et al. (2016) on onion and Mustafa et al. (2016) on okra.

3.3- The effects of the interactions

Respecting the interaction effect between nitrogen fertilization levels and stimulative treatments, the results in Tables (8-11) were demonstrated significant interaction effect for the entire yield and its components characters, during the two seasons of study.

| Table 8. The main effects of nitrogen levels, stimulative treatments and their interactions on pods number plant\(^{-1}\) and pods weight plant\(^{-1}\) of common bean cv. Nebraska, during 2015 season |
|-------------------------------------------------|
| **Stimulative treatments** | **Nitrogen levels (kg fad\(^{-1}\))** | **Pods number plant\(^{-1}\)** | **Pods weight Plant\(^{-1}\) (g)** |
|--------------------------|---------------------------------|---------------------------------|---------------------------------|
|                          | 0 | 20 | 40 | 60 | Mean |
| Control                  | 5.33j | 6.66-g-j | 7.66e-j | 9.22b-i | 7.22C |
| AH1                      | 6.11ij | 9.11-b-i | 9.44b-h | 9.55b-g | 8.55BC |
| AH2                      | 6.55g-j | 8.44-c-j | 10.55b-e | 11.33b-d | 9.22AB |
| FA1                      | 6.33g-j | 8.11-d-j | 11.00b-d | 11.00b-d | 9.11AB |
| FA2                      | 6.66g-j | 7.22-f-j | 10.22b-f | 11.44bc | 8.89AB |
| Trp1                     | 6.33-g-j | 8.67-c-i | 10.11b-f | 12.11ab | 9.30AB |
| Trp2                     | 6.22h-j | 9.22-b-i | 10.66b-e | 14.66a | 10.19A |
| Mean                     | 6.22D | 8.20C | 9.95B | 11.33A | |

*The mean values with the same alphabetical letters do not differ significantly at 0.05% probability level.*
Table 9. The main effects of nitrogen levels, stimulative treatments and their interactions on seeds weight plant$^{-1}$ and seeds yield fad$^{-1}$ of common bean cv. Nebraska, during 2015 season

| Stimulative treatments | 0      | 20     | 40     | 60     | Mean  |
|------------------------|--------|--------|--------|--------|-------|
| Control                | 6.29g  | 9.66c-g| 10.81b-e| 11.60b-d| 9.59B |
| AH1                    | 6.98fg | 10.81b-e| 10.94b-e| 11.92b-d| 10.16B|
| AH2                    | 8.31d-g| 11.55b-d| 11.71b-d| 12.06b-d| 10.91AB|
| FA1                    | 8.46d-g| 11.46b-d| 11.36b-d| 13.35a-c| 11.16AB|
| FA2                    | 7.41e-g| 10.02c-f| 11.52b-d| 14.14ab| 10.77AB|
| Trp1                   | 8.40d-g| 9.71c-g | 12.65a-c| 13.12a-c| 10.97AB|
| Trp2                   | 10.40b-f| 10.13c-f| 13.27a-c| 16.14a | 12.49A |
| Mean                   | 8.04C  | 10.48B | 11.75AB | 13.19A |       |

Table 10. The main effects of nitrogen levels, stimulative treatments and their interactions on pods number plant$^{-1}$ and pods weight plant$^{-1}$ of common bean cv. Nebraska, during 2016 season

| Stimulative treatments | 0    | 20   | 40   | 60   | Mean |
|------------------------|------|------|------|------|------|
| Control                | 9.55j| 11.78e-i| 13.44a-f| 13.22a-g| 12.00B |
| AH1                    | 11.33g-j| 13.44a-f| 14.00a-c| 12.44b-i| 12.80B |
| AH2                    | 9.55j| 13.11a-g | 12.44b-i| 13.78a-d| 12.22B |
| FA1                    | 10.99b-j| 12.11c-i| 13.22a-g| 12.44b-i| 12.19B |
| FA2                    | 10.89h-j| 12.78b-h| 12.11c-i| 13.77a-d| 12.39AB|
| Trp1                   | 10.55l-j| 12.00d-i| 12.66b-h| 13.66a-e| 12.22AB|
| Trp2                   | 11.55j-i| 12.78b-h| 14.77a  | 14.22ab | 13.33A |
| Mean                   | 10.63B| 12.57A | 13.23A | 13.36A |       |

* The mean values with the same alphabetical letters do not differ significantly at 0.05% probability level.
In addition, the obtained results pointed out that the combined application of 60 Kg N fad\(^{1}\) nitrogen fertilization and Trp2 was given the highest mean values of pods No. plant\(^{-1}\), seed weight plant\(^{-1}\) and seed yield fad\(^{-1}\), and the increments as an average of the two seasons for Trp2 were more pronounced than other stimulative treatments estimated by 26.67\%. These findings are in agreement with the results of by El-Awadi (2011), who is found that the interaction between nitrogen level and methionine and tryptophan foliar application had a significant effect on the total yield of snap bean and pod weight in both seasons.

The correlations between leaves elemental contents of N, P, K and common bean yield appeared to have high positive and significant values in both seasons as appears in Tables (12 and 13). Therefore, yield increments observed in this study could in part be attributed to higher N, P, K levels induced by nitrogen fertilizer and stimulative treatments and was more pronounced with tryptophan treatments.

According to the results of this study, it could conclude that the foliar application of tryptophan at 1 gL\(^{-1}\) combined with nitrogen fertilization at the rate of 60 Kg N fad\(^{-1}\), might be considered as an optimal treatment for plant growth and productivity of common bean, under the prevailing environmental conditions of El-Beheira Governorate and other similar regions.

| Stimulative treatments | Nitrogen levels (kg fad\(^{1}\)) | Seeds weight plant\(^{-1}\) (g) | Seeds yield fad\(^{1}\) (kg) |
|------------------------|---------------------------------|--------------------------------|-----------------------------|
|                        | 0                               | 20                             | 40                          | 60                          | Mean                      |
| Control                | 12.64l                          | 16.98h-l                       | 17.97f-j                    | 21.53b-f                    | 17.28B                    |
| AH1                    | 15.97h-l                        | 20.25c-h                       | 20.29c-h                    | 24.54a-c                    | 20.26A                    |
| AH2                    | 14.52j-l                        | 19.11d-i                       | 21.64b-f                    | 22.66a-e                    | 19.48AB                   |
| FA1                    | 15.73i-l                        | 16.04h-l                       | 22.63a-e                    | 24.64a-c                    | 19.76A                    |
| FA2                    | 18.39e-j                        | 18.20f-j                       | 21.42b-g                    | 26.36a                      | 21.09A                    |
| FA1                    | 13.06f-k                        | 18.75e-j                       | 24.53a-c                    | 25.34ab                     | 20.42A                    |
| Trp2                   | 17.09g-k                        | 19.50d-i                       | 23.38a-d                    | 25.58ab                     | 21.38A                    |
| Mean                   | 15.34D                          | 18.40C                         | 21.69B                      | 24.38A                      |                           |

|                          | Seeds weight plant\(^{-1}\) (g) |
|------------------------|---------------------------------|
| Control                | 1044.71l                        |
| AH1                    | 1319.86h-l                      |
| AH2                    | 1199.77j-l                      |
| FA1                    | 1299.76i-l                      |
| FA2                    | 1519.27e-j                      |
| Trp1                   | 1079.14k                        |
| Trp2                   | 1411.86g-k                      |
| Mean                   | 1267.77D                        | 1403.32h-l | 1485.12f-j | 1779.00a-f | 1428.04B |
| Control                | 1673.51c-h                      | 1767.27c-h | 2027.99a-c | 1674.41A   |
| AH1                    | 1579.04d-i                      | 1878.09b-f | 1872.65a-c | 1609.89AB  |
| AH2                    | 1325.37h-l                      | 1870.17a-e | 2035.98a-c | 1632.82A   |
| FA1                    | 1503.57f-j                      | 1769.91b-g | 2178.38a   | 1687.42A   |
| FA2                    | 1549.57e-j                      | 2026.89a-c | 2094.10ab  | 1742.78A   |
| Trp1                   | 1610.99d-i                      | 1932.14a-d | 2113.38ab  | 1767.09A   |
| Trp2                   | 1520.77C                        | 1792.66B | 2014.50A   |

* The mean values with the same alphabetical letters do not differ significantly at 0.05% probability level.

### Table 11. The main effects of nitrogen levels, stimulative treatments and their interactions on seeds weight plant\(^{-1}\) and seeds yield fad\(^{1}\) of common bean cv. Nebraska, during 2016 season

| Stimulative treatments | Nitrogen levels (kg fad\(^{1}\)) | Seeds weight plant\(^{-1}\) (g) |
|------------------------|---------------------------------|--------------------------------|
| Control                | 12.64l                          | 16.98h-l                       |
| AH1                    | 15.97h-l                        | 20.25c-h                       |
| AH2                    | 14.52j-l                        | 19.11d-i                       |
| FA1                    | 15.73i-l                        | 16.04h-l                       |
| FA2                    | 18.39e-j                        | 18.20f-j                       |
| FA1                    | 13.06f-k                        | 18.75e-j                       |
| Trp2                   | 17.09g-k                        | 19.50d-i                       |
| Mean                   | 15.34D                          | 18.40C                         |

### Table 12. Correlation between seed yield of common bean cv. Nebraska and leaf N, P, K Contents as affected by nitrogen fertilization and foliar application of stimulative treatments during 2015 season

|          | N  | P  | K  |
|----------|----|----|----|
| HA       |    |    |    |
| Seed yield plant\(^{-1}\) | 0.89 * | 0.96 * | 0.84 * |
| FA       |    |    |    |
| Seed yield plant\(^{-1}\) | 0.97 * | 0.99 * | 0.97 * |
| Trp      |    |    |    |
| Seed yield plant\(^{-1}\) | 0.99 * | 1.0 *  | 0.98 * |
Table 13. Correlation between seed yield of common bean cv. Nebraska and leaf N, P, K Contents as affected by nitrogen fertilization and foliar application of stimulative treatments during 2016 season

|                  | N   | P   | K   |
|------------------|-----|-----|-----|
| Seed yield plant | 0.94*| 0.96*| 0.97*|
| HA               |     |     |     |
| FA               |     |     |     |
| Seed yield plant | 0.96*| 0.94*| 0.98*|
| Trp              |     |     |     |
| Seed yield plant | 0.99*| 0.99*| 0.98*|

**REFERENCE**

Abbas, S.H., M.U. Sohail, M.U. Saleem, T.A. Mahmood, I.R. Aziz, M.A. Qamar, A.B. Majeed and M.U. Arif. (2013). Effect of L-tryptophan on plant weight and pod weight in chickpea under rainfed conditions. Sci. Tech. Dev.; 32 (4): 277-80.

Abd El-Wahed, M.S.A., M.E. El-Awadi, D.M. Salama and W.M. Haggag. (2016). Application of nitrogen, tryptophan and their relation on growth, yield and some chemical constituents in green onion. J. Chem. Pharm. Res., 8: 694-701.

Abou El-Yazied, A. and M.A. Mady. (2012). Effect of boron and yeast extract foliar application on growth, pod setting and both green pod and seed yield of broad bean (Vicia faba L.). J. Appl. Sci. Res., 8: 1240-1251.

Almeida, O., H.C.D. Melo and T.D.A. Portes. (2016). Growth and yield of the common bean in response to combined application of nitrogen and paclobutrazol. Revista Caatinga, 29 (1): 127-132.

Amin, A.A., M.E. Awadi, M.G. Dawood, F.A.E. Gharib and E.A. Hassan. (2014). Kinetin and tryptophan enhance yield and production efficiency of lupine (Lupinus termis L.) plants. World Rural Observations, 6 (4): 50-6.

Bazzano, L.A., J. He, L.G. Ogden, C. Loria, S. Vupputuri, L. Myers and P.K. Whelton. (2001). Legume consumption and risk of coronary heart disease in US men and women: NHANES I Epidemiologic Follow-up Study. Archives of Internal Medicine, 161 (21): 2573-2578.

Bekaert, S., S. Storozhenko, P.Mehrshahi, M.J. Bennett, W.Lambert, J.F. Gregory III, K.Schubert, J. Hugenholtz, D. Van Der Straeten, and J.D. Henson. (2008). Folate biofortification in food plants. Trends Plant Sci. 13: 28–35.

Buetow, R., G.H. Mehring, H. Kandel, B. Johnson, and J.M. Osorno. (2017). Nitrogen Fertilization and Inoculation Effects on Dry Bean. Agricultural Sciences, 8 (10): 1065.

Canellas, L.P., F.L. Olivares, N.O. Aguiar, D.L. Jones, A. Nebbiosio, P Mazzei and A. Piccolo. (2015). Humic and fulvic acids as biostimulants in horticulture. Scientia Horticulurae, 156: 19-27.

Chapman, H.D., P.F. Pratt. (1978). Methods of Analysis for Soils, Plants and Waters. Division of Agric. Sci., Univ. of California, USA, pp. 305.

Chen, M. C., B. Cheng, Q. Zhang, Ding, Z. P. Yang and P. Liu. (2005). Effects of applying L-methionine, L-phenylalanine and L-tryptophan on Zea mays growth and its nutrient uptake. Chin J Appl Ecol (in Chinese), 16: 1033–1037.

Chen, Y. and T. Aviad. (1990). Use of humic acid for crop production. J. Am Soc. of Agronomy, 12 (3): 86-90.

Dawood, M.G. and M.S. Sadak. (2007). Physiological response of canola plants (Brassica napus L.) to tryptophan or benzyladenine. Lucrari Stiintifice, 50 (9): 198-207.

El-Awadi, M.E., A.M. El-Bassiony, Z.F. Fawzy and M.A. El-Nemr. (2011). Response of snap bean (Phaseolus vulgaris L) plants to nitrogen fertilizer and foliar application with methionine and tryptophan. Nature and science, 9 (5): 87-94.

El-Bassiony, A.M., Z.F. Fawzy, M.A. El-Baky and A.R. Mahmoud. (2010). Response of snap bean plants to mineral fertilizers and humic acid application. Res. J. Agric. Biol. Sci., 6 (2): 169-175.

El-khatib, H.A. (2009). Growth and Yield of Common Bean (Phaseolus vulgaris L) in Response to Rhizobium Inoculation, Nitrogen and Molybdenum Fertilization. Alexandria Science Exchange Journal, 30 (2), pp.319-332.

Fageria, N.K. (2016). The use of nutrients in crop plants. CRC press.

Faostat, F.A.O. (2017). Statistical databases. Food and Agriculture Organization of the United Nations.

Frankenberger, J.W.T. and M. Arshad (1995) Microbial synthesis of auxins. Phytohormones in soils. Marcel Dekker, New York, pp.35-71.

Frankenberger, W.T. and M. Arshad. (1991). Yield response of watermelon and muskmelon to L-tryptophan applied to soil. HortScience, 26 (1): 35-37.

Frankenberger, W.T., A.C. Chang. and M. Arshad. (1990). Response of Raphanus sativus to the auxin precursor, L-tryptophan applied to soil. Plant and Soil, 129 (2): 235-241.

Gabr, S.M., H.A. El-khatib. and A.M. el-keriawi. (2007). effect of different biofertilizer types and nitrogen fertilizer levels on growth, yield and chemical contents of pea plants (Pisum sativum L.). J. Adv. Agric. Res. 6 (4): 939-955.

Gepts, P., 2001. Phaseolus vulgaris (beans). Encyclopedia of genetics, pp.1444-1445.
Gregorich, E., H.H. Janzen, B. Helgason. and B. Ellert. (2015). Chapter Two—Nitrogenous Gas Emissions from Soils and Greenhouse Gas Effects. Advances in agronomy, 132: 39-74.

Hefni, M.V. Öhrvik, M. Tabekha. and C. Witthöft. (2010). Folate content in foods com-monly consumed in Egypt. J. Food Chem. 121: 540–545.

Hegazi, A.Z., S.S. Mostafa. and H.M. Ahmed. (2010). Influence of different cyanobacterial application methods on growth and seed production of common bean under various levels of mineral nitrogen fertilization. Nature and Science, 8 (11): 183-194.

Hussein, M.M., S.Y. Faham. and A.K. Alva. (2014). Role of Foliar Application of Nicotinic Acid and Tryptophan on Onion Plants Response to Salinity Stress. Journal of Agricultural Science, 68: 41-51.

Ju, X.T., G.X. Xing, X.P. Chen, L.J. Zhang, X.J. Liu, Z.L. Cui, B. Yin, P. Christie, Z.L. Zhu. and F.S. Zhang. (2009). Reducing environmental risk by improving N management in intensive Chinese agricultural systems. Proceedings of the National Academy of Sci., 106 (9): 3041-3046.

Kalyoncu, O., S. Akinci. and E. Bozkurt. (2017). The effects of humic acid on growth and ion uptake of mung bean (Vigna radiata (L.) Wilczek) grown under salt stress. African Journal of Agricultural Research, 12 (49): 3447-3460.

Kamel, S.M., M.M. Afifi, F.S. El-shoraky. and M.M. El-Sawy. (2014). Fulvic acid: a tool for controlling powdery and downy mildews in cucumber plants. International Journal of Phytopathology, 3 (2): 101-108.

Kandi, M.A.S., A. Toheb, A. Golipour, S.J. Godehkahriz. and Z. Rastgar. (2012). Concentration changes of lysine and methionine amino acids in potatoes varieties affected by different levels of Nitrogen fertilizer. Tech J Eng Appl Sci 2 (4):93–96 alfalfa. J Plant Nutr., 8: 1103–1121

Leghari, S.J., N.A. Wahocho, G.M. Laghari, A. Hafeez Laghari, G. Mustafa Bhabhan, K. Hussain Talpur, T.A. Bhotto, S.A. Wahocho. and A.A. Lashari. (2016). Role of nitrogen for plant growth and development: A review. Advances in Environmental Biology, 10 (9): 209-219.

Losak, T., J. Hlusek, R. Filipcik, L. Pospisilova, J. Manasek, K. Prokes. and F. Orosz. (2010). Effect of nitrogen fertilization on metabolisms of essential and non-essential amino acids in field-grown grain maize (Zea mays L.). Plant Soil Environ 56 (12): 574–579.

Maathuis, F. J. (2009). Physiological functions of mineral macronutrients. Current opinion in plant biology, 12 (3): 250-258.

Malan, C. (2015). November. Review: humic and fulvic acids. A Practical Approach. In Sustainable soil management symposium. Stellenbosch (pp. 5-6).

Marschner, H., 2012. Marschner's mineral nutrition of higher plants (third edd.). Academic press.

Marinari, S., G. Masicandaro, B. Ceccanti. and S. Grego. (2000). Influence of organic and mineral fertilisers on soil biological and physical properties. Bioresource technology, 72 (1): 9-17.

Mustafa, A., A. Hussain, M. Naveed, A. Ditta, Z.E.H. Nazli. and A. Sattar. (2016). Response of okra (Abelmoschus esculentus L.) to soil and foliar applied L-tryptophan. Soil & Environment, 35 (1): 76-84.

Omar, N. (2013). Effect of foliar fertilizer with nutritional compound and humic acid on growth and yield of broad bean plants under sandy soil conditions. Journal of Applied Sciences Research, 9(6): 674-3680.

Page, A.L., R.H. Miller. and D.R. Keeney. (1982). Methods of Soil Analysis, Part 2, 2nd Edition. Agronomy Monograph, Vol. 9. American Society of Agronomy. Madison, WI, 1142 pp.

Pavlíková, D., M. Neuberg, E. Zizkova, V. Motyka. and M. Pavlík. (2012). Interactions between nitrogen-nutrition and phytohormone levels in Festulolium plants. Plant Soil Environ 58: 367–372.

Reddy, M., Malla. Padmaja, B. Reddy. and R. Ram. 2010. Response of French bean to irrigation schedules and nitrogen levels in Talangana region of Andhra Pradesh. J. Food Legumes, 23(1): 38-40.

Rizwan, A., A. Khalid, M. Arshad, Z. A. Zahir and T. Mahmood. (2008). Effect of compost enriched with N and L-tryptophan on soil and maize. Agronomy for Sustainable Development. 28: 299–305.

Scaglia, B., R.R. Nunes, M.O.O. Rezende, F. Tambone. and F. Adani. (2016). Investigating organic molecules responsible of auxin-like activity of humic acid fraction extracted from vermicompost. Science of the Total Environment, 562: 289-295.

Selim, E. M., A. A. Mosa. and A. M. El-Ghamry. (2009). Evaluation of humic substances fertigation through surface and subsurface drip irrigation systems on potato grown under Egyptian sandy soil conditions, Agr. Water Manage., 96: 1218-1222.

Sharif, M. (2002). Effect of lignitic coal derived humic acid on growth and yield of wheat and maize in alkaline soil (Doctoral dissertation, Nwfp Agricultural University Peshawar, Pakistan).

Singh, R.V. (2000). Response of french bean to plant spacing, and nitrogen, phosphorus fertilization. Indian J. Hort. 57 (4): 338-341.

Soratto, R.P., T.A. Catuchi, E.D.F.C.D. Souza. and J.L.N. Garcia. (2017). Plant density and nitrogen fertilization on common bean nutrition and yield. Revista Caatinga, 30 (3): 670-678.

Suh, H.Y., K.S. Yoo. and S.G. Suh. (2014). Effect of foliar application of fulvic acid on plant growth and fruit quality of tomato (Lycopersicon esculentum L.). Horticuture, Environment, and Biotechnology, 55 (6): 455-461.

Temminghoff, E.E. and V.J. eds. Houba. (2004). Plant analysis procedures (Vol. 179). Dordrecht: Kluwer Academic Publishers.
Tilman, D., C. Balzer, J. Hill and B. L. Belfort. (2011). Global food demand and the sustainable intensification of agriculture. Proc. Natl. Acad. Sci. U. S. A. 108, 20260–20264.

Tilman, D., K. G. Cassman, P. A. Matson, R. Naylor and S. Polasky. (2002). Agricultural sustainability and intensive production practices. Nature, 418 (6898): 671.

Yamauchi, M., S. Katayama, T. Todoroki and T. Watanable. (1984). Total synthesis of fulvic acid. Journal of the Chemical Society, Chemical Communications. 23: 1565-1576.

Zahir, A. Z., M. A. ur Rahman Malik and M. Arshad. (2000). Improving crop yield by the application of an auxin precursor L-TRP. Pak. J. Biol. Sci., 3: 133-135.

Zahir, Z. A., H. M. Yasin, M. Naveed, M. A. Anjum, and M. Khalid. (2010). L-tryptophan application enhances the effectiveness of rhizobium inoculation for improving growth and yield of mung bean (Vigna radiata (L.) Wilczek). Pak J Bot., 42 (3): 1771-1780.

الملخص العربي

تأثير مستويات مختلفة من تسميد النتروجيني مع الرش الورقي بكل من الهيومك والفولفيك والتريبتوفان على النمو والانتاجية والمحصول الكيميائي لنباتات الفاصوليا (Phaseolus vulgaris L.)

حسن أحمد الخطيب، سعيد محمد جبر، علاء الدين حسين رشدي، راضي سعد قاسي

azzi

Tilman, D., C. Balzer, J. Hill and B. L. Belfort. (2011). Global food demand and the sustainable intensification of agriculture. Proc. Natl. Acad. Sci. U. S. A. 108, 20260–20264.

Tilman, D., K. G. Cassman, P. A. Matson, R. Naylor and S. Polasky. (2002). Agricultural sustainability and intensive production practices. Nature, 418 (6898): 671.

Yamauchi, M., S. Katayama, T. Todoroki and T. Watanable. (1984). Total synthesis of fulvic acid. Journal of the Chemical Society, Chemical Communications. 23: 1565-1576.

Zahir, A. Z., M. A. ur Rahman Malik and M. Arshad. (2000). Improving crop yield by the application of an auxin precursor L-TRP. Pak. J. Biol. Sci., 3: 133-135.

Zahir, Z. A., H. M. Yasin, M. Naveed, M. A. Anjum, and M. Khalid. (2010). L-tryptophan application enhances the effectiveness of rhizobium inoculation for improving growth and yield of mung bean (Vigna radiata (L.) Wilczek). Pak J Bot., 42 (3): 1771-1780.