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.)

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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-Matamer 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

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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 Cº 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})				
	0	**20**	**40**	**60**	**Mean**
	Plant height (cm)				
Control	35.33f	42.56b-e	43.22a-e	44.57a-d	41.42B
AH1	36.22f	43.57a-d	44.57a-d	46.78ab	42.78AB
AH2	35.11f	44.55a-d	46.22ab	47.00ab	43.22AB
FA1	39.11d-f	43.10a-e	45.78a-c	47.00ab	43.75AB
FA2	37.00ef	43.53a-d	45.11a-d	46.89ab	43.13AB
Trp1	39.89c-f	43.34a-d	46.11a-c	49.11a	44.61A
Trp2	39.22d-f	44.89a-d	46.00a-c	47.22ab	44.33AB
Mean	37.41C	43.65B	45.29B	46.94A	
	Foliage fresh weight (g)				
Control	27.87h	38.11f-h	59.10a-e	68.00a-d	48.22B
AH1	30.64h	62.51a-d	66.00a-d	67.28a-d	56.61AB
AH2	36.63gh	56.75b-f	67.88a-d	70.31a-d	57.89A
FA1	31.48h	54.51d-g	67.70a-d	71.53a-d	56.30AB
FA2	29.46h	54.79d-g	64.71a-d	75.26ab	56.06AB
Trp1	38.36f-h	55.18c-g	74.20a-c	75.02ab	60.69A
Trp2	40.70e-h	54.92d-g	74.70ab	76.86a	61.79A
Mean	33.59C	53.82B	67.75A	72.01A	
	Foliage dry weight (g)				
Control	6.01i	7.10f-i	10.40b-g	11.97a-d	8.86B
AH1	6.28hi	9.10c-i	11.37a-e	12.32a-c	9.76AB
AH2	7.02g-i	8.79d-i	10.74b-e	13.31ab	9.96AB
FA1	6.10i	9.65c-h	10.50b-f	13.62ab	9.96AB
FA2	6.30hi	10.18b-g	10.90a-e	13.49ab	10.22AB
Trp1	7.02g-i	9.39c-i	11.12a-e	13.16ab	10.17AB
Trp2	8.01e-i	8.98c-i	12.11a-d	14.29a	10.84A
Mean	6.67D	9.02C	11.02B	13.17A	

* 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	Nitrogen levels (kg fad^{-1})				
	0	20	40	60	Mean
	Number of leaves plant^{-1}				
Control	9.33l-n	12.33i-n	15.66e-j	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	869.83f-h	1255.73d-e	1385.89cd	1047.25D
AH1	758.25gh	1030.23e-g	1226.99d-e	1429.88b-d	1111.34CD
AH2	833.84gh	1038.48e-g	1375.79cd	1640.50a-c	1222.15BC
FA1	718.39h	1150.01d-f	1623.10a-c	1748.21a	1309.93AB
FA2	753.83gh	1232.54de	1750.08 a	1789.98a	1381.61A
Trp1	820.46gh	1224.08de	1715.59ab	1629.65a-c	1347.44AB
Trp2	888.49f-h	1241.95de	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	Nitrogen levels (kg fad^{-1})				
	0	20	40	60	Mean
	Plant height (cm)				
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	6.00i-k	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})				
	0	20	40	60	Mean
	Number of leaves plant^{-1}				
Control	12.22e	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	
	Leaves area (cm^2)				
Control	687.22h	1235.82c-f	1285.57b-f	1401.45b-f	1152.51C
AH1	802.89gh	1229.42d-f	1318.56b-f	1515.26a-e	1216.53BC
AH2	1026.03f-h	1442.65b-e	1592.45a-d	1861.15a	1480.57A
FA1	1023.87f-h	1145.92e-g	1463.45a-e	1644.27a-c	1319.38A-C
FA2	1191.57d-g	1232.57d-f	1370.37b-f	1550.63a-e	1336.28A-C
Trp1	1159.67e-g	1339.92b-f	1309.51b-f	1673.50ab	1370.65AB
Trp2	1027.48f-h	1345.89b-f	1512.00a-e	1582.73a-d	1367.02AB
Mean	988.39C	1281.74B	1407.41AB	1604.14A	

* 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 60 Kg N fad^{-1} application for N, P, K and chlorophyll contents were 15.5, 24.44, 10.06 and 5.16%, respectively. The improving effects of nitrogen fertilizer on leaves chemical contents might be related to the vital role of nitrogen for the formation of chlorophyll pigments and stimulation of photosynthesis process (Marschner, 2012). Similar trends were reported by several researchers (Gabr *et al*., 2007 on pea and El-khatib, 2009 on bean). They stressed that the use of sufficient doses of nitrogen fertilization, significantly, improve chlorophyll and leaves chemical contents.

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 Trp2 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 Trp2 treatment for N, P and K contents were 6.25, 8.78 and 6.95% respectively. On the other hand, HA2 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 Trep1 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	3.22l-n	3.27j-n	3.38h-m	3.58d-h	3.36C
AH1	3.20mn	3.31i-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	3.23l-n	3.61c-f	3.52f-h	3.99a	3.59A
Mean	3.26C	3.44B	3.50B	3.76A	
			P%		
Control	0.421k	0.427jk	0.457h-j	0.528b-d	0.458D
AH1	0.419k	0.446i-k	0.462g-i	0.511c-f	0.459D
AH2	0.421k	0.441i-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	0.378l	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.

Table 7. The main effects of nitrogen levels, stimulative treatments and their interactions on leaves N, P, K and chlorophyll contents of common bean during 2016 season

Stimulative treatments	Nitrogen levels (kg fad^{-1})				
	0	20	40	60	Mean
			N%		
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	
			P%		
Control	0.39jk	0.41g-h	0.42g-i	0.49b	0.43D
AH1	0.40jk	0.43g-i	0.43g-i	0.50b	0.44CD
AH2	0.40i-j	0.42g-i	0.44d-g	0.48bc	0.43D
FA1	0.42g-i	0.43f-h	0.45c-f	0.49b	0.45BC
FA2	0.38k	0.44e-g	0.47bc	0.52a	0.45B
Trp1	0.40ij	0.44d-g	0.44d-g	0.54a	0.45B
Trp2	0.46cd	0.42g-i	0.46c-e	0.53a	0.47A
Mean	0.41C	0.43BC	0.44B	0.51A	
			K%		
Control	2.13j	2.28f-i	2.36c-h	2.32d-i	2.27C
AH1	2.21ij	2.21ij	2.28f-i	2.43a-e	2.28BC
AH2	2.21ij	2.39b-f	2.37b-g	2.41a-f	2.35B
FA1	2.20ij	2.29e-i	2.33d-i	2.45a-d	2.32BC
FA2	2.23h-j	2.24g-j	2.36b-h	2.50ab	2.33BC
Trp1	2.24g-j	2.25g-j	2.37b-g	2.54a	2.35B
Trp2	2.36b-h	2.39b-f	2.49a-c	2.48a-c	2.43A
Mean	2.23D	2.30C	2.37B	2.45A	
			Chlorophyll (SPAD)		
Control	36.06e	40.32a-d	40.53a-d	41.15a-d	39.51B
AH1	38.82de	41.57a-d	41.33a-d	41.97a-c	40.92AB
AH2	39.08cd	41.57a-d	41.65a-d	42.14ab	41.10A
FA1	39.17b-d	40.63a-d	41.32a-d	42.13ab	40.81AB
FA2	39.33b-d	41.00a-d	40.21a-d	42.42a	40.74AB
Trp1	39.57a-d	39.83a-d	41.03a-d	41.45a-d	40.47AB
Trp2	40.47a-d	40.89a-d	40.37a-d	41.00a-d	40.68AB
Mean	38.93C	40.83B	40.92AB	41.75A	

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

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}, 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,; Abbas *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})				
	0	20	40	60	Mean
			Pods number plant^{-1}		
Control	5.33j	6.66g-j	7.66e-j	9.22b-i	7.22C
AH1	6.11ij	9.11b-i	9.44b-h	9.55b-g	8.55BC
AH2	6.55g-j	8.44c-j	10.55b-e	11.33b-d	9.22AB
FA1	6.33g-j	8.11d-j	11.00b-d	11.00b-d	9.11AB
FA2	6.66g-j	7.22f-j	10.22b-f	11.44bc	8.89AB
Trp1	6.33g-j	8.67c-i	10.11b-f	12.11ab	9.30AB
Trp2	6.22h-j	9.22b-i	10.66b-e	14.66a	10.19A
Mean	6.22D	8.20C	9.95B	11.33A	
			Pods weight Plant^{-1} (g)		
Control	10.17i	13.14g-i	20.44c-e	19.86de	15.91C
AH1	10.77hi	15.04fg	18.32ef	22.78a-d	16.73C
AH2	12.25g-i	14.74fg	20.41c-e	21.74b-e	17.29BC
FA1	14.79fg	15.96fg	19.92de	23.62a-d	18.57AB
FA2	12.73g-i	14.36gh	22.87a-d	24.16a-c	18.53AB
Trp1	13.24g-i	14.87fg	25.00ab	25.25ab	19.59A
Trp2	12.55g-i	15.09fg	22.32a-d	25.87a	18.96AB
Mean	12.36D	14.74C	21.32B	23.33A	

* 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	Nitrogen levels (kg fad^{-1})				
	0	20	40	60	Mean
	Seeds wt. Plant^{-1} (g)				
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	
	Seeds yield fad^{-1} (kg)				
Control	520.01g	798.47c-g	892.90b-e	958.22b-d	792.40B
AH1	577.03fg	893.48b-e	903.96b-e	984.94b-d	839.85B
AH2	686.65d-g	954.10b-d	967.64b-d	996.78b-d	901.30AB
FA1	699.07d-g	946.93b-d	938.54b-d	1103.37a-c	921.98AB
FA2	612.02e-g	827.94c-f	951.68b-d	1168.65ab	890.07AB
Trp1	693.81d-g	802.71c-g	1045.23a-c	1083.82a-c	906.39AB
Trp2	859.67b-f	837.22c-f	1096.76a-c	1333.80a	1031.86A
Mean	664.04C	865.84B	970.96AB	1089.94A	

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

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	Nitrogen levels (kg fad^{-1})				
	0	20	40	60	Mean
	Pods number plant^{-1}				
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	10.99h-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	10.55i-j	12.00d-i	12.66b-h	13.66a-e	12.22AB
Trp2	11.55f-i	12.78b-h	14.77a	14.22ab	13.33A
Mean	10.63B	12.57A	13.23A	13.36A	
	Pods weight Plant^{-1} (g)				
Control	16.86j	22.93d-i	24.40b-h	28.40a-c	23.15B
AH1	21.40g-j	24.53b-h	26.24a-g	27.12a-f	24.82AB
AH2	20.31h-j	24.65b-h	27.53a-e	26.32a-f	24.70B
FA1	21.43g-j	22.32f-i	27.88a-c	27.96a-c	24.90AB
FA2	22.69e-i	22.58f-i	26.68a-f	28.56ab	25.13AB
Trp1	19.43i-j	23.67c-i	26.22a-g	29.21ab	24.63B
Trp2	24.66b-h	26.53a-f	27.59a-d	30.01a	27.20A
Mean	20.97C	23.89B	26.65A	28.22A	

* 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})				
	0	20	40	60	Mean
	Seeds weight plant^{-1} (g)				
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
Trp1	13.06kl	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 yield fad^{-1} (kg)				
Control	1044.71l	1403.32h-l	1485.12f-j	1779.00a-f	1428.04B
AH1	1319.86h-l	1673.51c-h	1676.27c-h	2027.99a-c	1674.41A
AH2	1199.77j-l	1579.04d-i	1788.09b-f	1872.65a-e	1609.89AB
FA1	1299.76i-l	1325.37h-l	1870.17a-e	2035.98a-c	1632.82A
FA2	1519.27e-j	1503.57f-j	1769.91b-g	2178.38a	1687.42A
Trp1	1079.14kl	1549.57e-j	2026.89a-c	2094.10ab	1742.78A
Trp2	1411.86g-k	1610.99d-i	1932.14a-d	2113.38ab	1767.09A
Mean	1267.77D	1520.77C	1792.66B	2014.50A	

* 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 at1 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.

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
	HA			
Seed yield plant^{-1}		0.94 *	0.96 *	0.97 *
	FA			
Seed yield plant^{-1}		0.96 *	0.94 *	0.98 *
	Trp			
Seed yield plant^{-1}		0.99 *	0.99 *	0.98 *

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الملخص العربي

تأثير مستويات مختلفة من اتسميد النتروجيني مع الرش الورقي بكل من الهيومك والفولفيك والتريبتوفان على النمو والإنتاجية والمحتوى الكيماوي لنباتات الفاصوليا (*Phaseolus vulgaris* **L.**)

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أجريت تجربتان حقليتان خلال الموسمين المتتاليين لعامي 2015 و2016 في المزرعة التجريبية. كلية الزراعة، جامعة دمنهور- محافظة البحيرة بهدف دراسة تأثير مستويات متزايدة من التسميد النيتروجينى المعدنى (صفر، 20، 40 ،60 كيلو جرام نيتروجين/فدان) مع ثلاثة أنواع مختلفة من المنشطات الحيوية (حمض الهيوميك 1 و2 جم باللتر، حمض الفولفيك 2.5 و5 جم باللتر والتربتوفان 0.5 و1 جم/اللتر) والتداخلات بينهم على صفات النمو الخضرى ومحتوى الأوراق من الكلوروفيل والنيتروجين والفوسفور والبوتاسيوم وكذلك المحصول ومكوناته لنباتات الفاصوليا الجافه صنف نبراسكا0 ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى:

أدى إضافة السماد النيتروجينى المعدنى إلى زيادة معنوية فى جميع صفات النمو الخضرى ومحتوى الاوراق من الكلوروفيل والنيتروجين والفوسفور والبوتاسيوم والمحصول الجاف ومكوناته مقارنة بالنباتات الغير معاملة فى كل من الموسمين.

اظهرت الدراسه ان إضافة السماد النيتروجينى بمعدل 60 كجم نيتروجين/فدان ادى إلى زيادة معنوية فى كل الصفات موضع الدراسه وعلاوة علي ذلك ، فان اضافه المنشطات الحيوية اعطت اعلي القيم لمتوسطات النمو والمحتوى الكيماوى والمحصول مقارنه بالكنترول.

ومن ناحية أخرى كان التربتوفان أكثر تفوقا. وأوضحت النتائج أن إضافة السماد النيتروجيني المعدني بمعدل60 كجم نيتروجين/فدان بالإضافة الى التربتوفان بمعدل 1 جرام/لتر أعطى أعلى القيم المعنوية لمستويات التداخل لمحصول الفاصوليا الجاف مقارنة بالمعاملات الأخرى.