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EFFECT OF APPLICATION METHODS OF PLANT GROWTH STIMULANTS ON GROWTH AND YIELD OF SNAP BEAN

A.M. Shaheen, E.H. Abd El-Samad*, F.A. Rizk, A.G. Behairy and S.M. Adam

Vegetable Crops Research Department, Agricultural and Biological Research Division, National Research Centre (NRC), 33 El-Buhouth St. (former El-Tahrir St.), Dokki, Giza, Egypt, Postal Code: 12622
*Corresponding author's email: emadhassanein@hotmail.com

ABSTRACT

Plant growth stimulants have the potential to enhance plant growth and productivity as well as improve the plants adaptive/resistance to environmental stressors, particularly in newly reclaimed areas. Therefore, two field experiments were conducted during seasons of 2014/2015 and 2015/2016 under newly reclaimed sandy soil conditions at the Experimental and Production Station of National Research Centre, El-Noubaria region, Behera governorate, Egypt. In order to investigate the effect of application methods, pre-sowing seed soaking for 6 h or foliar spraying for three times starting at 15 days after seeding in 10 days interval on the efficiency of plant growth stimulants (amino acids 2.5 ml/l, IAA 150 ppm and GA_3 50 ppm as well as control treatment) on growth, yield and quality of snap bean cv. Paulista. The experiments were laid out in a split plot design with 3 replicates. The obtained results revealed that foliar spraying of plant growth stimulants was superior than seed soaking in improvement of plant vegetative growth parameters. Also, it gained the highest values of total pods yield as g/plant or ton/ha and pod physical characters in relative to seed soaking method. Moreover, it was evident that the application methods had no significant effect on the nutritional values of bean pods, except for K in the first season and Fe content in both seasons. Plant growth stimulants positively increased plant vegetative growth, pod yield and pod quality attributes over control treatment in both seasons. GA_3 (50 ppm) significantly increased plant vegetative growth, total pods yield (g/plant or ton/ha) and pod physical properties followed by amino acids treatment (2.5 ml/l) without significant differences between them. On the other hand, amino acids treatment gave the highest nutritional values of protein, N, P and K, while, the highest values of Fe, Mn, Zn and Cu contents were attained by GA_3 treatment. The interaction effect had significant differences on most of measured parameters during both seasons of study. The most effective treatment was GA_3 (50 ppm) as foliar spraying on vegetative growth, total pods yield and yield attributes as well as amino acids (2.5 ml/l) even as foliar spraying or seed soaking on pod nutritional values.

Keywords: Snap bean, Seed soaking, Foliar spraying, GA_3, IAA, Amino acids, Plant vegetative growth, Pods yield and quality.

INTRODUCTION

Snap bean (*Phaseolus vulgaris* L.) is one of the most important legumes crops cultivated in Egypt for local consumption as green pods or dry seeds. Whereas, it represents a cheap source of protein and carbohydrate in human diets for a large sector of the Egyptian inhabitants, especially in the rural areas. Moreover, it is one of the main exported crops, the total exported amount reached to 22.5 thousand tons in 2015 according to agriculture statistics. Globally, Egypt is ranked as a number sixth (with a total production amount of 251.3 thousand tons) among top ten green beans producers (FAOSTAT, 2012).

As one of the main exported crops, efforts should be directly focused towards increasing and improving bean pods yield and quality. The target could be achieved either by horizontal expansion (cultivation in newly reclaimed areas) or by vertical expansion (using advanced agronomical practices or various agrochemical substances for plant growth stimulating), but taking into account, the environmental risks which threatened human health (Tilman *et al.,* 2002).

Plant growth stimulant substances are materials, those promote plant growth when applied in low quantities, such as plant growth promoting rhizobacteria (PGPR), yeast, seaweed extracts, humic acid, amino acids, chitosan, antioxidants as well as plant growth regulators. They have been shown to influence several metabolic processes and enhance plant growth and development, yield and nutrient contents (Kauffman *et al.,* 2007; Qureshi *et al.,* 2009; Jardin, 2015).

Amino acids as organic nitrogenous compounds, is well known as a plant growth stimulant which has positive effects on plant growth, yield, quality and significantly alleviating the environmental stresses (Raeisi *et al.,* 2013; Shalaby and El-Ramady, 2014). Saeed *et al*. (2005) reported that amino acids treatment significantly improved vegetative growth parameters and pod yield in soybean. In the same regard, Hanafy *et al.* (2010) demonstrated that foliar application of amino acids significantly increased all studied vegetative growth characters, yield and its components. In addition improved N, K, Mg, Zn, Mn, Fe and protein concentration in snap bean pods. Also, Zewail (2014) indicated that increasing amino acids sprayed level from 2 to 8 ml/l led to increase all measured growth characteristics, yield and yield components as well as biochemical constituents of N, P, K, Mg, Ca, Fe, Zn, total carbohydrates and crude protein of common bean.

Gibberellins play a major role in all growth processes like seed germination and development, seed germination rate, stimulating stem and root growth, controlling of flowering time and even organ elongation (Yamaguchi, 2008). Many investigators studied the role of GA_3 on some vegetable plants and coming to the opinion that, GA_3 caused an enhancement in plant growth and productivity (Pavlista *et al.,* 2012; Rathod *et al.,* 2015). Manal *et al.* (2015) indicated that foliar spraying of GA_3 had positive significant effects on growth, yield and yield components of faba bean plants. Moreover, foliar treatments significantly improved nutritional status of faba bean plants and seed carbohydrates, protein and nutrients content. Leite *et al.* (2003) concluded that application of GA_3 at rate of 50 mg/l as soybean seed treatment resulted in decreasing plant emergence and initial root growth, and presented a decrease in the number of nodes, stem diameter, leaf area and dry matter yield. Conversely, foliar application of GA_3 at 100 mg/l led to an increase in plant height, leaf area, stem diameter and dry matter production, but no effects on the number of leaves, number of stem branches and root dry matter were realized.

Auxins might regulating cell division, cell elongation, tissue swelling, formation of adventitious roots, callus initiation, induction of embryogenesis and promoting cell wall loosening at very low concentrations (Vanderhoef and Dute, 1981), enhanced photosynthetic activities (Naeem *et al.,* 2004). Also activated the translocation of metabolic materials (Awan *et al.,* 1999). IAA showed a favorable effect on flower retention and subsequently on yield of lentil (Khalil *et al.,* 2006). Hayam and Abd El-Rheem (2015) found that IAA foliar application of bean plants led significantly to increase number of leaves, leaf area, number of pod and pod yield. N, P and K contents as well as soluble protein and total carbohydrates in leaves were also increased when the application rate of IAA treatment increased to the higher rate (225 ppm). Moreover, Abd El-Rheem *et al.* (2015) showed that application of IAA at rate of 150 ppm gave the highest values of N, P and K contents in leaves of wheat under different rates of N fertilization. In addition, IAA treatments caused significant increases in seed yield/plant, seed yield/ha and yield attributes (number of pods/plant, pods yield/plant and 100-seed weight) of two faba bean cultivars (Mervat *et al.,* 2013). Further, foliar application of NAA at 90 ml/ha increased the grain yield and had significant beneficial effects on the yield attributes of coarse rice (Bakhsh *et al.,* 2011).

Mostafa and Gamal (2015) reported that the improvement of vegetative growth characters of bean plants as well as total pods yield and its consistent were more pronounced when using foliar spraying of some plant growth active substances than seed soaking. Furthermore, Hamed and Jalal (2012) reported that foliar application of some bio-organic nutrient on maize plants after emergence is more favorable on plant vegetative growth when compared with the pre-sowing seed treatment.

The present study was conducted to study the efficiency of plant growth stimulants (amino acids 2.5 ml/l, IAA 150 ppm and GA_3 50 ppm), applied as pre-sowing seed soaking for 6 h or foliar spraying for 3 times starting at 15 days after seeding, in 10 days interval on plant growth, pods yield and quality as well as pod nutritional values of snap bean plants grown under newly reclaimed sandy soil conditions.

MATERIALS AND METHODS

Two field experiments were carried out at the Experimental Station of National Research Centre in El-Noubaria region, Behera governorate, Egypt (latitude 30° 72' 66" and longitude 30° 20' 18"), during seasons of 2014/2015 and 2015/2016 under newly reclaimed soil conditions. The soil of the experimental site is sandy in texture with 95.3% sand, 0.4% silt and 4.3% clay. The pH and ECe of soil extract as well as the percentages of $CaCO_3$ and organic matter were 7.9, 2.0 dsm^{-1}, 5.20 and 0.26%, respectively.

To study the influence of application methods (seed soaking or foliar spraying) of plant growth stimulant substances (amino acids, IAA and GA_3) on growth and productivity of snap bean plants, seeds of snap bean cv. Paulista were obtained from Horticultural Research Institute, Agricultural Research Center, Giza, Egypt. Seeds were divided into 2 groups, the first group was soaked for a period of 6 hours in plant growth stimulant substances (amino acids at rate of 2.5 ml/l, IAA at rate of 150 ppm and GA_3 at rate of 50 ppm as well as distilled water served as a control treatment). Amino acids, naturally amino acid stimulant, known commercially as AMINO MIX (obtained from AGRICO International Co., Egypt, www.agricointernational.com), is a mixture of natural amino acids and micronutrients. The chemical composition of AMINO MIX is shown in Table (1). While, IAA and GA_3 were purchased from Sigma-Aldrich Chemicals Company, St. Louis, USA. Afterward, soaked seeds were directly sown. Whereas, the second group was sown directly without soaking, subsequently, such plants were foliar sprayed by plant growth stimulant substances with the same concentration used for pre-sowing seed soaking treatment, for three times starting at 15 days after seeding (second true leaf stage) in 10 days interval. All sprays were done in the early morning using a hand pressure sprayer and covering the plant foliage with spraying solution.

Experimental design: The experiments were laid out in a split plot design with 3 replicates. The experiment include 8 treatments which were the simple combinations between the two methods of application (seed soaking or foliar spraying), and the plant growth stimulant substances (amino acids, IAA and GA_3 as well as control treatment). The two methods of application were distributed in the main plots and the plant growth stimulant substances were randomly arranged within the sub-plots.

All sub-plots were fertilized by compost at rate of 20 ton/ha and phosphorus at 100 units P_2O_5/ha as calcium super-phosphate (15.5% P_2O_5). Full dose of both compost and phosphorus was applied during the final preparation of experimental soil and thoroughly mixed with the soil. Whereas, nitrogen fertilizer was added 30 days after seeding at rate of 70 units N/ha as a starter dose in the form of ammonium sulphate (20.6% N). Potassium sulphate was also added at rate of 115 units of K_2O/ha as potassium sulphate (48% K_2O), 45 days after sowing date.

The two groups of seeds (soaked group or foliar sprayed group) were sown on October 2, 2014 for the first season and on October 5, 2015 for the second season in hills with 3 seeds per hill and 25 cm apart at both sides of 3 drip irrigated ridges with 5 meters length and 70 cm width, the total area of each sub-plot was 10.5 m^2. The sown seeds were drip irrigated regularly for 30 min daily for 1 week until the completion of seed germination. Then bean seedlings were drip irrigated for 90 min every 2 days until the experiment termination. In addition, two weeks after sowing, bean seedlings were thinned to one seedling per hole. Furthermore, the standard agricultural practices of hoeing, fertilization, controlling of pest, disease and weed for snap bean production in the growing area were applied according to the recommendations of Ministry of Agriculture and Land Reclamation.

Vegetative growth parameters: A random sample of 6 plants from each experimental sub-plot was randomly taken 50 days after sowing for determination of the following measurements, plant height (cm), number of leaves/plant, number of shoots/plant, total leaf area per plant (cm^2), fresh and dry weight of whole plant and its leaves and shoots (g).

Pods yield and pod quality attributes: During harvesting stage (70 days after sowing date), the total green pods from each experimental sub-plot were collected along the harvesting period and the following data were recorded: average weight of pods per plant (g), average number of pods per plant. Also total pods yield (ton/ha) was calculated. Moreover, 25 snap bean pods were taken randomly from the third and fourth harvestings from each experimental sub-plot to determine pod physical properties i.e. the average of pod length (cm), pod diameter (mm) and weight of pod (g).

Nutritional values of snap bean pods: Furthermore, an additional sample of 25 pods from the third and fourth harvestings, were randomly selected from each experimental sub-plot for nutritional values measurements. Pods were oven dried at 70^oC until constant weight. Then dried pod samples were fine grinded and wet digested as described by Wolf (1982). Acid digested solution of dried pod samples was used to determine mineral contents on a dry weight basis. Total nitrogen was determined using micro Kjeldahl method according to the procedures described by Cottenie *et al*. (1982). Phosphorus percentage was assayed according the modified colorimetric (molybdenum blue) method using spectrophotometer (SPECTRONIC 20D, Milton Roy Co. Ltd., USA) according to the procedures described by Cottenie *et al*. (1982). While, potassium percentage was measured using flame photometer method (JENWAY, PFP-7, ELE Instrument Co. Ltd., UK) as described by Chapman and Pratt (1982). Concerning micro-elements contents, Fe, Mn, Zn and Cu, atomic absorption (ANALYST 200, Parkin Elmer, Inc., MA, USA) was used to determine as described by Chapman and Pratt (1982). Moreover, total crude protein in pods was calculated by multiplying nitrogen percentage value by conversion factor 6.25.

Statistical analysis: All obtained data were tabulated and subjected to statistical analysis of variance procedure using two-way-ANOVA of the SPSS software (SPSS Inc., 2002, release 16, Chicago, IL, USA). Mean of the treatments were separated and compared by using the least significant differences (LSD) test at ($P \leq 0.05$) level of significance according to the procedures reported by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Plant vegetative growth parameters: The obtained results sharply indicated that foliar spraying method was superior than seed soaking method in both seasons of 2014-15 and 2015-16 (Tables 2 and 3). Whereas, the foliar spraying method significantly increased ($P<0.05$) the values of plant height, leaf area, fresh and dry weight of leaves and shoots as well whole plant in both seasons of study. Except for number of leaves/plant and dry weight of whole bean plant in the second season only. No significant differences were realized between the two application methods (seed soaking or foliar spraying) on the average numbers of leaves and shoots/plant in both seasons of 2014-15 and 2015-16.

Generally, it could be explained the superiority of foliar spraying method than seed soaking ones on vegetative growth characters of snap bean plants, due to that the hardness of snap bean seed coat which, required a long period of soaking more than 6 hours for absorbing an effective amount of growth stimulants solution (seed imbibitions). In addition foliar spraying treatments carried out for three times on leaves surface of bean canopy which could be received the growth stimulants solution and absorbed the active substances directly in a short time. Consequently influenced the plant physiological and metabolic processes. The focused studies on the effect of application methods are inadequate. The obtained results are in good accordance with those of Hamed and Jalal (2012) and Mostafa and Gamal (2015). They stated that foliar spraying method of organic nutrients or growth stimulants is more favorable on plant vegetative growth characters than the pre-sowing seed soaking treatment.

Concerning the effect of plant growth stimulants, GA_3 treatment at rate of 50 ppm significantly ($P<0.05$) recorded the highest values of plant vegetative growth characters followed in descending order by amino acids (2.5 ml/l) and IAA (150 ppm) treatments. Whereas, control treatment gained the lowest values of plant vegetative growth parameters (Tables 2 and 3). These findings were true in both seasons of study, except for average number of leaves/plant in the first season, where, GA_3 treatment followed by IAA treatment, and plant height in the second season, where, the highest value was recorded by amino acids treatment followed by IAA treatment.

It is of interest to note that, in most cases no significant differences were detected between GA_3 and amino acids treatments and between IAA and control treatments during both seasons. On the other hands, significant differences were detected only between GA_3 and IAA as well as control treatments. It could be stated that the GA_3 treatment as a plant growth stimulants was superior than amino acids and IAA treatments in enhancing or promoting the vegetative growth of bean plants in both seasons of 2014-15 and 2015-16 (Tables 2 and 3).

The previous results of Abdel-Mawgoud *et al*. (2011) and Zewail (2014) on green bean, Maral *et al*. (2012) on cowpea, Saeed *et al*. (2005) on soybean and Raeisi *et al.* (2013) on broad bean are supported the obtained data. In the same respect, Hanafy *et al.* (2010) cleared that foliar application of amino acids significantly increased plant height as well as number of leaves and branches/plant of snap bean plants. They also added that the effect of amino acids might be due to their roles in enhancing many physiological processes and their metabolism. Moreover, Tantawy *et al.* (2009) revealed that using the mixture of amino acids, tended to be effective in enhancing plant growth in tomato, where the amino acids mixture contained many amino acids which necessary for plant growth as well as alleviating environmental stresses. Also, many investigators studied the role of GA_3 in growth and productivity of some vegetable crops and they coming to the opinion that, it's caused an enhancement in plant growth and productivity such as Ibrahim *et al.* (2007) and Manal *et al.* (2015) on faba bean and Rathod *et al.* (2015) on French bean.

The interaction had significant differences effect on all plant growth measurements, except on the average number of shoots/plant in both seasons of study (Tables 2 and 3). The highest values of plant height, number of leaves/plant, total leaf area, fresh and dry weight of whole plant and its leaves and shoots during the first season, were recorded by bean plants which treated by GA_3 applied as foliar spraying, followed by those plants treated with amino acids as foliar application without significant differences between them, and then by bean plants which received GA_3 as seed soaking method. While, in the second season, the highest values of vegetative growth characters were recorded by those plants which treated by GA_3 as foliar application and the second order was fluctuated among treatments of amino acids as foliar spraying, GA_3 as seed soaking and amino acid as seed soaking. It could be declared that GA_3 treatment gave the superiority in all plant vegetative growth measurements with both application methods during the two seasons of 2014-15 and 2015-16.

Total pods yield and yield attributes: Foliar application method led to an increase in total pods yield and pod physical properties more than seed soaking method. A significant difference ($P<0.05$) was observed only on average weight of pod and total pods yield (g/plant and ton/ha) in both seasons of 2014-15 and 2015-16 (Table 4). The foliar spraying method of plant growth stimulants resulted in the heaviest total pods yield (8.57 and 7.81 tons/ha) when compared with pre-sowing seed soaking method (5.95 and 6.81 tons/ha) during the first and second seasons, respectively. It could be summarized that the superiority of foliar spraying method in total pods yield over than seed soaking ones was amounted by 30.57 and 12.8%, in the first and second seasons, respectively. Similar trends were observed on the response of pod physical properties (pod length, pod diameter and pod weight) to the method of application.

Briefly, it could be stated that the foliar application method resulted the higher total pods yield and pod physical properties than seed soaking method (Table 4). This might be attributed to the favorable effect of foliar application method on the vegetative plant growth. The obtained results are in good accordance with Mostafa and Gamal (2015) on bean plant, they reported that using foliar spraying of some growth active substances caused an enhancement in total pods yield and its constituents than seed soaking method.

Application of plant growth stimulant substances (amino acids, IAA, GA_3) positively increased total pods yield and pod physical properties over control treatment in both seasons of study (Table 4). Snap bean plants which treated with GA_3 (50 ppm) gave the heaviest total pods yield (g/plant and ton/ha) as well as the highest values of average pod numbers/plant, average weight of pod, pod diameter and pod length followed in descending order by those plants of amino acids (2.5 ml/l) treatment, however, no significant differences were detected between both of them, and by IAA treated plants (150 ppm). On the contrary, control treatment gave the lowest values of total pods yield as g/plant and ton/ha, average pod numbers/plant, pod diameter, pod length and the average weight of pod. Significant differences were detected only between GA_3 and control treatments as well as IAA treatment in both seasons of study.

Exogenous application of GA_3 seems to enhance all growth processes and stimulate stem and root growth which may be led to increase plant productivity. Many investigators studied the role of GA_3 on some vegetable plants and coming to the opinion that, GA_3 caused an enhancement in plant productivity such as Ibrahim *et al.* (2007) and Manal *et al.* (2015) on *Vicia faba* and Rathod *et al.* (2015) on French bean. They indicated that foliar spraying of GA_3 had positive significant effects on yield and yield components. In addition, foliar spraying of NAA at 90 ml/ha significantly increased grain yield and yield attributes of coarse rice (Bakhsh *et al.,* 2011).

The favorable effect of applied amino acids (AMINO MIX), might be attributed to that it contains more amino acids, vitamins and some nutritional elements (Table 1). Whereas, amino acids is well known as plant growth stimulant which has positive effects on plant growth, yield and significantly alleviating the injuries caused by abiotic stresses (Kowalczyk and Zielony, 2008; Ahmed *et al.,* 2014). Also previous studies have been proved that amino acids can directly or indirectly influenced the physiological activities of the plant. Results obtained by Maral *et al.* (2012) on cowpea, Raeisi *et al.* (2013) on faba bean and Hanafy *et al.* (2010) and Zewail (2014) on bean are in agreement with the obtained results herein. In additions, Saeed *et al.*(2005) found that amino acids treatment significantly improved pods yield of soybean.

Plant growth substances are well known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates to sink, thereby helping in effective flower formation, fruit and seed development and ultimately enhancing the productivity of crops (Ammanullah *et al.,* 2010).

The interaction between plant growth stimulants and their applying methods had significant difference effects on total pods yield and pod physical properties during both seasons of 2014-15 and 2015-16 (Table 4). It is evident from the obtained results that the plant growth stimulants treatments even as foliar spraying or pre-sowing seed soaking caused an enhancement of pods yield and pod physical properties relative to control treatment during both seasons of study.

It is of interest to clarify that snap bean plants treated by GA_3 as foliar spraying or seed soaking gave the heaviest pods yield (g/plant and ton/ha) and the highest values of pod numbers/plant, average weight of pod, pod diameter and pod length followed by those plants treated with amino acids as foliar spraying in both seasons of study. Except for average weight of pod and pods yield as g/plant parameters, whereas the highest values were recorded with amino acids treatment as foliar spraying in the first season only. No significant differences were noticed among bean plants treated with GA_3 as foliar spraying or pre-sowing seed soaking as well as bean plants treated with amino acids as foliar application. In the same regard, no significant differences were detected between IAA and control treatments. Significant differences were detected only among GA_3 treatment as foliar or seed soaking and control treatments as well as IAA even as foliar or seed soaking treatment.

Nutritional values of snap bean pods: The application methods of plant growth stimulants had no significant effect on the nutritional values of snap bean pods during both seasons of 2014-15 and 2015-16 (Tables 5 and 6). Except for the percentage of K content only in the first season and Fe content in both seasons. In spite of no significant effect of the method of application, but in general, it seemed that foliar application method of plant growth stimulants caused a marked enhancement of the nutritional values of snap bean pods i.e. percentages of protein, N, P and K as well as Fe, Mn, Zn and Cu contents more than seed soaking method during both seasons of study.

Foliar application method increased plant growth measurements, which reflected on the enhancement of plants vigorous to build more metabolic processes which consequently reflected on the absorption more nutrient elements from the root zone, hence the concentration of these elements increased in plant tissues.

Snap bean plants treated by amino acids led significantly to an enhancement in the percentages of protein, N, P and K of pods tissue followed by GA_3 treatment. While, the highest values of Fe, Mn, Zn and Cu contents were recorded by GA_3 treatment followed by amino acids treatment. On the contrary, control treatment gave the lowest values of nutritional values of snap bean pods in both seasons of study.

The statistical analysis of the obtained data markedly revealed that there were no significant differences detected among plant growth stimulants treatments on Fe and Cu contents in the first season and on Mn content in both seasons. In the same respect, no significant differences were realized between amino acids and GA_3 treatments in both seasons of study. Significant differences ($P<0.05$) were detected only between amino acids or GA_3 treatments and control or IAA treatments (Tables 5 and 6).

The previous results concluded that GA_3 and amino acids caused an increment in plant vegetative growth of snap bean plants, consequently enhanced the efficiency of bean plants to absorb more elements from rhizosphere, hence it expected to increase the mineral contents in snap bean plants and pods.

Concerning to the effect of amino acids on the chemical constituents of snap bean pods, many researchers such as Hanafy *et al.* (2010) and El-Awadi *et al*. (2011) have been proved that amino acids can directly or indirectly influenced the physiological activity of plant yield and its chemical constituents. Also, Zewail (2014) indicated that increasing amino acids sprayed level led to increase all biochemical constituents of N, P, K, Mg, Ca, Fe and Zn as well as total carbohydrates and crude protein of common bean. Whereas, Manal *et al.* (2015) indicated that foliar spraying of GA_3 significantly improved nutritional status of faba bean plants and seeds carbohydrates, protein and nutrients contents.

The interaction between application methods and plant growth stimulant substances recorded significant differences effect on the nutritional values of snap bean pods parameters i.e. the percentages of protein, N, P, K and Fe contents in the first season and on protein, N, P, Fe and Zn in the second season. However, the obtained results clearly demonstrated that the interaction had no significant differences effect between GA_3 applied as foliar spraying or pre-sowing seed soaking treatment. Also between amino acids treatment even as foliar spraying or seed soaking on nutritional values of snap bean pods in both seasons of 2014-15 and 2015-16 (Tables 5 and 6).

Amino acids as seed soaking treatment gave the highest values of protein, N and P in the first season and protein, N and Mn in the second season. While, amino acids as foliar spraying treatment gave the highest value of K percentage in the first season and P percentage in the second season. In the same respect, GA_3 as foliar spraying treatment gave the highest values of Fe, Mn, Zn and Cu contents in the first season and Fe, Zn and Cu contents in the second season. Whereas, the highest percentage of K in the second season was obtained by GA_3 as seed soaking treatment. However, the lowest values of nutritional values of snap bean pods parameters were obtained with control treatment even as seed soaking or foliar spraying in both seasons of study. Generally, It could be concluded that the superiority of most nutritional values of snap bean pods were obtained when bean plants treated by amino acids as foliar spraying or seed soaking during both seasons of study.

Table 1. Chemical composition of AMINO MIX compound.

Nutritional elements g/100 ml		Amino acids mg/100 ml				Vitamins mg/100 ml	
Zn	2.0	**Aspartic acid**	249	**Methionine**	180	**Vitamin B_1**	0.8
Fe	1.5	**Threonine**	45	**Iso-Leucine**	52	**Vitamin B_2**	2.4
Mn	0.5	**Serine**	56	**Tyrosine**	38	**Vitamin B_6**	1.2
Mg	0.004	**Glutamic acid**	55	**Phenylalanine**	22	**Vitamin B_{12}**	0.82
Cu	0.004	**Glycine**	50	**Histidine**	12	**Folic acid**	4.2
Ca	0.025	**Alanine**	100	**Lysine**	40	**Pantothenic acid**	0.52
Br	0.056	**Proline**	38	**Arginine**	20	**Nicotine B_5**	1.14
S	0.01	**Valine**	68	**Tryptophan**	20	**Ascorbic**	1.0
Co	0.03	**Cysteine**	44				

Table 2. Effect of application methods of plant growth stimulants on vegetative growth characters of snap bean during the first season of 2014-15.

Treatments	Plant height (cm)	Number of		Leaf area cm^2 /plant	Fresh weight g/plant			Dry weight g/plant		
		Leaves	Shoots		Leaves	Shoots	Whole	Leaves	Shoots	Whole
A- Applying methods										
Seed soaking	75.60	15.25	3.72	775.4	133.8	127.5	261.3	25.9	24.6	50.5
Foliar spraying	86.65	22.42	4.00	868.03	144.5	137.5	282.0	30.2	28.7	58.9
L.S.D. at 5%	**4.53**	**N.S.**	**N.S.**	**13.5**	**4.33**	**5.33**	**6.66**	**1.66**	**2.51**	**1.75**

B- Plant growth stimulants											
Control		71.6	18.1	3.2	632.1	102.2	118.1	220.3	17.4	21.6	39.0
Amino acids		87.6	22.0	4.1	847.8	168.3	134.9	303.2	33.7	30.6	64.3
IAA		75.2	22.8	3.8	818.7	110.4	124.0	234.4	24.6	22.9	47.5
GA_3		90.3	24.1	4.4	987.1	175.8	152.9	328.7	36.5	31.6	68.1
L.S.D. at 5%		**4.71**	**3.10**	**0.75**	**67.1**	**10.55**	**12.06**	**36.60**	**5.17**	**2.61**	**4.66**
C- Applying methods x Plant growth stimulants											
Seed soaking	**Control**	65.4	17.2	3.1	601.8	103.4	114.9	218.3	17.7	18.6	36.3
	Amino acids	80.0	20.3	4.2	771.4	158.0	129.6	287.6	31.1	29.1	60.3
	IAA	72.1	23.0	3.3	895.4	107.0	124.8	231.8	19.8	21.4	41.2
	GA_3	85.9	23.0	4.3	920.0	166.9	140.5	307.5	34.9	29.1	64.7
Foliar spraying	**Control**	77.8	18.4	3.3	662.4	100.9	121.2	222.1	17.1	24.5	41.6
	Amino acids	94.1	23.7	4.0	924.3	178.6	140.3	325.0	36.3	32.1	68.4
	IAA	79.2	22.5	4.3	832.5	113.7	123.2	236.9	29.4	24.3	53.7
	GA_3	95.5	25.1	4.4	1054.2	184.8	165.4	344.0	38.1	34.0	72.1
L.S.D. at 5%		**13.51**	**6.71**	**N.S.**	**103.1**	**23.6**	**10.66**	**29.56**	**6.66**	**4.20**	**15.33**

Table 3. Effect of application methods of plant growth stimulants on vegetative growth characters of snap bean during the second season of 2015-16.

Treatments		**Plant height (cm)**	**Number of**		**Leaf area cm^2 /plant**	**Fresh weight g/plant**			**Dry weight g/plant**		
			Leaves	**Shoots**		**Leaves**	**Shoots**	**Whole**	**Leaves**	**Shoots**	**Whole**
A- Applying methods											
Seed soaking		75.15	20.10	3.7	769.7	129.7	120.9	250.6	24.2	24.6	48.8
Foliar spraying		83.7	20.9	4.0	841.6	148.7	142.6	291.3	28.2	29.8	28.0
L.S.D. at 5%		**3.61**	**N.S.**	**N.S.**	**9.66**	**5.15**	**7.19**	**11.50**	**2.33**	**1.75**	**4.70**
B- Plant growth stimulants											
Control		66.9	17.3	3.5	623.9	104.6	96.6	201.2	19.3	21.9	41.2
Amino acids		85.9	22.1	4.3	883.3	151.7	145.5	297.0	31.5	29.6	61.1
IAA		76.9	18.4	3.9	685.3	122.1	125.3	247.4	20.9	25.1	46.0
GA_3		67.9	24.3	4.4	1030	178.4	156.8	335.2	33.1	32.2	65.3
L.S.D. at 5%		**6.33**	**2.66**	**6.39**	**13.1**	**13.66**	**13.11**	**21.91**	**4.76**	**3.67**	**5.11**
C- Applying methods x Plant growth stimulants											
Seed soaking	**Control**	64.0	16.8	3.3	591.3	103.4	79.9	183.3	19.9	19.2	39.1
	Amino acids	81.0	22.9	3.9	895.4	135.4	146.8	282.1	27.2	26.5	54.2
	IAA	72.9	17.6	3.4	635.3	107.9	104.4	212.2	21.1	21.2	42.3
	GA_3	82.7	23.0	4.1	956.8	172.1	152.5	324.6	28.2	31.5	29.7
Foliar spraying	**Control**	69.9	17.7	3.4	656.6	105.9	118.4	224.3	18.7	24.7	43.4
	Amino acids	90.9	21.2	4.4	871.3	168.0	144.4	312.4	35.3	32.7	60.0
	IAA	80.9	19.1	3.8	735.3	136.3	146.2	282.5	20.8	29.1	49.9
	GA_3	93.1	25.6	4.4	1103.0	184.2	161.2	345.9	38.0	32.9	70.9
L.S.D. at 5%		**11.66**	**3.33**	**N.S.**	**77.6**	**17.75**	**30.31**	**40.0**	**8.61**	**6.51**	**12.63**

Table 4. Effect of application methods of plant growth stimulants on total pods yield and pods physical properties of snap bean during both seasons of 2014-15 and 2015-16.

Treatments		First season (2014-15)						Second season (2015-16)					
		Pod wt (g)	Pod physical properties			Yield		Pod wt (g)	Pod physical properties			Yield	
			Length	Diameter	No./plant	g/plant	ton/ha		Length	Diameter	No./plant	g/plant	ton/ha
A- Applying methods													
Seed soaking		9.62	6.86	0.76	9.65	86.2	5.95	11.65	6.83	0.69	7.75	96.77	6.81
Foliar spraying		11.42	7.04	0.79	10.15	124.0	8.57	14.17	6.94	0.72	7.90	104.77	7.81
L.S.D. at 5%		**0.761**	**N.S.**	**N.S.**	**N.S.**	**13.66**	**0.357**	**0.866**	**N.S.**	**N.S.**	**N.S.**	**5.13**	**0.243**
B- Plant growth stimulants													
Control		6.77	6.15	0.63	8.35	56.5	4.05	7.99	5.74	0.62	7.18	57.4	3.98
Amino acids		13.43	7.68	0.79	10.35	139.5	9.52	16.63	7.32	0.76	8.16	127.9	8.95
IAA		8.03	6.31	0.69	9.86	88.0	6.19	9.42	6.66	0.63	7.63	72.05	5.36
GA3		13.87	7.86	0.89	11.05	153.0	10.48	18.72	7.80	0.80	8.32	155.7	10.98
L.S.D. at 5%		**2.66**	**0.666**	**0.133**	**1.75**	**36.6**	**0.938**	**3.19**	**1.361**	**0.151**	**0.873**	**39.11**	**2.208**
C- Applying methods x Plant growth stimulants													
Seed soaking	**Control**	6.14	6.10	0.61	8.3	51.0	3.57	7.99	5.73	0.61	7.01	56.0	3.88
	Amino acids	11.48	7.55	0.83	10.1	46.0	8.10	14.86	7.11	0.75	8.1	120.4	8.48
	IAA	6.35	6.30	0.71	9.6	61.0	4.29	7.71	6.66	0.63	7.56	58.3	4.07
	GA3	14.53	7.50	0.88	10.6	154.0	10.95	18.29	7.80	0.77	8.33	152.4	10.83
Foliar spraying	**Control**	7.38	6.21	0.66	8.4	62.0	4.29	7.99	5.75	0.63	7.36	58.8	4.07
	Amino acids	15.38	7.81	0.75	10.6	165.0	10.95	18.40	7.53	0.77	8.21	135.4	9.43
	IAA	9.70	6.31	0.68	10.1	98.0	6.90	11.13	6.67	0.64	7.71	85.8	6.62
	GA3	13.22	7.83	0.91	11.5	152.0	11.19	19.15	7.81	0.83	8.31	159.1	11.09
L.S.D. at 5%		**2.16**	**0.55**	**0.131**	**1.66**	**22.15**	**0.731**	**3.33**	**1.33**	**0.16**	**0.61**	**66.33**	**1.982**

Table 5. Effect of application methods of plant growth stimulants on nutritional values of snap bean pods during the first season of 2014-15.

Treatments		%				ppm		
		Protein	N	P	K	Fe	Mn	Zn	Cu
A- Applying methods									
Seed soaking		5.68	0.91	0.12	0.38	6.25	0.13	0.20	0.18
Foliar spraying		5.75	0.92	0.13	0.42	6.33	0.14	0.21	0.20
L.S.D. at 5%		**N.S.**	**N.S.**	**N.S.**	**0.03**	**0.13**	**N.S.**	**N.S.**	**N.S.**
B- Plant growth stimulants									
Control		4.68	0.75	0.09	0.36	5.57	0.12	0.17	0.14
Amino acids		6.53	1.04	0.16	0.48	6.82	0.14	0.20	0.21
IAA		5.31	0.85	0.12	0.36	6.27	0.13	0.20	0.16
GA_3		6.21	0.99	0.14	0.38	6.93	0.15	0.25	0.24
L.S.D. at 5%		**0.81**	**0.13**	**0.03**	**0.04**	**N.S.**	**N.S.**	**0.04**	**N.S.**
C- Applying methods x Plant growth stimulants									
Seed soaking	**Control**	4.12	0.66	0.08	0.36	5.20	0.12	0.16	0.13
	Amino acids	6.75	1.08	0.16	0.42	6.71	0.14	0.20	0.20
	IAA	5.37	0.86	0.11	0.36	6.39	0.13	0.20	0.16
	GA_3	6.37	1.02	0.15	0.37	6.70	0.14	0.24	0.24
Foliar spraying	**Control**	5.25	0.84	0.10	0.35	5.94	0.12	0.18	0.16
	Amino acids	6.31	1.01	0.16	0.55	6.93	0.14	0.21	0.23
	IAA	5.25	0.84	0.13	0.37	6.15	0.14	0.20	0.16
	GA_3	6.06	0.97	0.14	0.40	7.17	0.16	0.26	0.25
L.S.D. at 5%		**1.03**	**0.16**	**0.036**	**0.13**	**1.33**	**N.S.**	**N.S.**	**N.S.**

Table 6. Effect of application methods of plant growth stimulants on nutritional values of snap bean pods during the second season of 2015-16.

Treatments		%				ppm			
		Protein	N	P	K	Fe	Mn	Zn	Cu
A- Applying methods									
Seed soaking		8.91	1.43	0.13	0.38	6.62	0.14	0.19	0.23
Foliar spraying		8.87	1.42	0.14	0.37	6.97	0.13	0.21	0.21
L.S.D. at 5%		**N.S.**	**N.S.**	**N.S.**	**N.S.**	**0.15**	**N.S.**	**N.S.**	**N.S.**
B- Plant growth stimulants									
Control		6.09	0.97	0.10	0.33	6.11	0.12	0.14	0.18
Amino acids		12.15	1.99	0.16	0.41	7.01	0.14	0.21	0.22
IAA		7.21	1.15	0.14	0.37	6.33	0.13	0.19	0.21
GA_3		10.09	1.61	0.15	0.40	7.63	0.14	0.25	0.27
L.S.D. at 5%		**1.33**	**0.167**	**0.041**	**0.086**	**0.211**	**N.S.**	**0.076**	**0.066**
C- Applying methods x Plant growth stimulants									
Seed soaking	**Control**	5.87	0.94	0.10	0.35	5.76	0.12	0.13	0.19
	Amino acids	12.25	1.96	0.15	0.41	6.95	0.15	0.21	0.25
	IAA	7.81	1.25	0.14	0.38	6.16	0.13	0.18	0.23
	GA_3	9.69	1.55	0.15	0.49	7.41	0.14	0.24	0.27
Foliar spraying	**Control**	6.31	1.01	0.11	0.31	6.47	0.12	0.16	0.18
	Amino acids	12.06	1.93	0.17	0.42	7.07	0.14	0.22	0.18
	IAA	6.62	1.06	0.14	0.37	6.50	0.14	0.20	0.21
	GA_3	10.50	1.68	0.15	0.40	7.86	0.14	0.26	0.27
L.S.D. at 5%		**1.66**	**0.751**	**0.033**	**N.S.**	**0.66**	**N.S.**	**0.066**	**N.S.**

Conclusion: It could be concluded that, foliar spraying of some plant growth stimulants is more favorable than pre-sowing seed soaking treatment in concern of growth, total pods yield and yield attributes as well as nutritional values of snap bean pods. The most effective treatment was GA_3 as foliar spraying on vegetative growth, total pods yield and yield attributes as well as amino acids even as foliar spraying or seed soaking treatment on pod nutritional values.

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