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IMPROVING THE PRODUCTIVITY AND QUALITY OF SNAP BEAN BY USING FOLIAR APPLICATION OF AMINO ACIDS AND SOME ANTIOXIDANTS

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ABSTRACT: *Two field trials were conducted at the Experimental Farm of the Faculty of Agriculture, Tanta University, Egypt, during the summer growing seasons of 2008 and 2009, to study the influence of spraying the canopy of snap bean cv. "Paulista" with various concentrations of antioxidants mixture of vitamin C, salicylic acid and citric acid at five concentrations 0, 100, 150, 200 and 250 ppm, whilst amino acids were foliar sprayed at 0, 0.25 and 0.50 mg/l, on vegetative growth, pods yield and its components and some chemical constituents of leaves and pods The amino acids were foliar sprayed at 15, 30, 45, 60 and 75 days after planting date, also Antioxidants mixture were foliar sprayed at 21, 35, 49 and 63 days after planting date. The obtained results revealed that spraying snap bean plants with 0.25 and 0.50 mg/l of amino acids improved vegetative growth parameters, yield and its components and chemical composition of leaves and pods. The highest values of vegetative growth parameters, yield and its components and chemical composition of leaves and pods were obtained from spraying phaseolus plants with antioxidants substances at 150, 200 and 250 ppm, all treatments values were higher than the control. In general, foliar application of both amino acids at 0.50 mg/l. and antioxidant substances at 150, 200 and 250 can be recommended for improving growth and yield of snap bean under clay loam soil.*

Key Words: *amino acids, antioxidants substances, Snap Bean (Phaseolus vulgaris L.), productivity, quality*

INTRODUCTION

Snap bean (*Phaseolus vulgaris* L.) is the world's most important food legume. Beans are important for the human nutrition in Egypt, where middle and low income families are often unable to have a sufficient animal protein for their feeds (Elkhatib *et al* 2008). Furthermore, beans provide substantial quantities of minerals and vitamins, complex carbohydrates, dietary fiber, flavones, antioxidants and anticarcinogenic compounds (Bennink, 2001). The total area planted in Egypt with snap bean cultivars was 137242 feddans with a total annual production of 247336 ton of green beans (FAO, 2008).

Recently, great attention has been focused on natural and safety antioxidant substances and amino acids. Antioxidants (such as vitamin C, salicylic acid, citric acid....etc) have the ability to quench free radicals and thereby form a protective screen around plant cells and hence increasing

plant resistance to stress and provide adequate protection against the deleterious effects of activated oxygen species (Alscher *et al* 1997, Wada and Ou, 2002, Karadeniz *et al* 2005 and Kamel and Abd Al-Gaid. 2008). Antioxidants as active oxygen scavengers protect the structure and function of the photosystems aginst excess light and play an important role in the reduction or prevention of enzymatic browing by inhibiting polyphenol oxidase (Rajagopal *et al* 2005). Salicylic acid as antioxidant has positive effect on plant growth and it can counteract the harmful effect of some environmental stresses on plant growth (El-Khayat, 2001). It has been previously reported that citric acid can stimulate nutrients absorption and hastenes growth activators synthesis (Abd El-Naem, 2005). Ascorbic acid (vitamin C) functions as an antioxidant, an enzyme factor and as a growth regulating factor. It participates in a variety of processes including photosynthesis, photoprotection, cell wall growth and cell expansion, resistance to environmental stresses and synthesis of ethylene, gibberellins, anthocynins and hydroxyproline (Nicholas and Wheeler, 2000).

Much work has been recently conducted on several natural compounds including amino acids to be applied as a foliar feeding to increase the growth and yield of economical crops as a biostimulant. Amino acids are the fundamental ingredients for the process of protein synthesis (Strove, 1986). The importance of amino acids came from their widely use for the biosynthesis of a large variety of nonproteinic nitrogenous materials, *i.e.*, pigments, vitamins, coenzymes, purine and pyrimidine bases. Studies have proved that amino acids can directly or indirectly influence the physiological activities in plant growth and development (Al-Said and Kamal, 2008).

The current study was suggested in order to assess the influence of spraying the canopy of bean cv. "Paulista" with various concentrations of antioxidants substances (mixture of vitamin C, salicylic acid and citric acid) and amino acids on vegetative growth, pods yield and its components and some chemical constituents of leaves and pods.

MATERIALS AND METHODS:

Chemicals

Antioxidant substances were obtained from El-Gomhouria Chemicals Co., Egypt while, amino acids were obtained from APC Europe Co., AV san julian-Spain (in Egypt UAD Co.). Amino acids (Pepton 85/16) as powder from of different amino acids were as follows:

Alanine = 6.90 %	Arginie = 5.22 %	Aspartic acid = 9.93 %
Cystine = 2.25 %	Glycine = 4.06 %	Glutaminc acid = 7.25 %
Histidine = 6.34 %	Isoleucine = 0.15 %	Leucine = 10.99 %
Lysine = 7.19 %	Metionine = 0.71 %	Phenylalanine = 5.93 %
Serine = 3.88 %	Threonine = 2.47 %	Tryptophan = 0.68 %
Tyrosine = 1.92 %	Valine =6.79 %	Proline = 2.84 %
Total amino acids = 85.5%		Free L-α amino acids = 16 %
Organic Nitrogen = 12 %		Potassium oxide = 2.5 %

The Amino acids contained in Pepton 85/16 contained amino acids in L-α type

Chemical composition of the Soil

Field experiments were conducted in clay loam soil. Chemical analysis of the soil was determined according to Ryan *et al* (1996) and the results were as follows:

pH = 7.94	HCO_3 = 5.29 meq/l
E.C. = 2.95 mmhos	Cl^- = 8.37 meq/l
Mg^{++} = 4.74 meq/l	N = 32.9 (mg / 100g soil)
Na^+ = 12.94 meq/l	P = 7.4 (mg / 100g soil)
Ca^{++} = 6.68 meq/l	K^+ = 167.5 (mg / 100g soil)

Plant material

Seeds of snap bean cv. "Paulista" were sown on 1st and 3rd of March in the first and the second seasons, respectively.

Experimental Design:

The experimental layout was split-plot with three replicates. Amino acids with three concentrations of 0, 0.25 and 0.50 mg/l were randomly distributed in the main plots whereas; Antioxidants mixture of vitamin C, salicylic acid and citric acid at five concentrations (0, 100, 150, 200 and 250 ppm) were in the sub-plots. The amino acids were foliar sprayed at 15, 30, 45, 60 and 75 days after planting date. Antioxidants were foliar sprayed at 21, 35, 49 and 63 days after planting date.

Each sub-plot was 12 m^2, including 5 rows, each of 4 m length and 60 cm width and one plant per hill with 7 cm apart was left. The cultural practices were done according to the recommendation of Ministry of Agriculture, Egypt.

Recorded Data

Vegetative growth characters

Five plants were randomly chosen from each sub plot at 60 days from sowing to measure the vegetative growth characters including plant height (cm), number of leaves and branches per plant, leaf area per plant (cm^2), plant fresh weight (g), plant dry weight (%), stem diameter (cm). Leaf area per plant (cm^2) was estimated using the weight method as reported by Fayed (1997):

$$\text{Leaf area in } cm^2 = \frac{\text{Leaves fresh wt. x leaf area of disks}}{\text{Fresh wt. of disks}}$$

Green pods yield and its components

Pod length (cm), pod diameter (cm), average pod weight (gm), pod dry weight (%), number of pods/plant, early pods yield (ton/fed.) and total pods yield (ton/fed.) were recorded at harvest time.

To obtain the early pods yield/feddan, the first four pods that have been appeared on the plant were harvested from each treatment and weighted.

Total pods yield/feddan, all pods that have been harvested from each treatment over all the harvesting time were weighted, and calculated then converted to ton /feddan.

Chemical composition

Nitrogen (%), phosphorus (%), potassium (%) and total chlorophyll (mg/100g f.w), content of pods and leaves, fiber content of pods (%) and total sugar content of pods (%) were determined following to Association of Official Analytical Chemists International (A.O.A.C) (1995). The total protein percentage of seeds was calculated by the multiplication of nitrogen values by 6.25%.

Statistical analysis

Data were analyzed by MSTATC computer software program adopted by Bricker, (1991) using ANOVA with the least significant difference (LSD) at the 0.05 probability level.

RESULTS AND DISCUSSION:

Vegetative growth

It is obvious from data in Tables (1&2) that foliar application of amino acids at both concentrations (0.25 and 0.50 mg/l) significantly increased plant height, leaf area/plant and plant fresh weight in both seasons, except for number of leaves/plant and plant dry weight that were significant only in the second season. On the other side, number of branches per plant and stem diameter were not affected in both seasons. The highest values of all characters were obtained when amino acids were used at 0.50 mg/l.

The promotional effect of amino acids on plant development of snap bean plants may be due to the regulatory effects of certain amino acids on plant development through their influence on enhancing production of gibberellins in plant tissues (Waller and Nowaki, 1978). Moreover, amino acids are the starting materials for the synthesis of alkaloids and various products of secondary metabolisms (Strove, 1986). El-Nabarawy (2001) illustrated that the importance and role of amino acids in synthesizing processes of chlorophyll and enzymes that are very important for growth and protein synthesis. The results were in harmony with those obtained by Kamar and Omar (1987) on cucumber and potato, Sharma and Kothari (1993) on mungbean. El-Shabasi *et al* (2005) on garlic, Awad *et al* (2007) on potato and Al-Said and Kamal, (2008) on sweet pepper,

Concerning the effect of the antioxidant treatments (mixture of vitamin C, salicylic acid and citric acid) on vegetative growth parameters of snap bean plants data in Tables (1&2) indicate that plant height, number of leaves/plant, leaf area/plant, plant fresh and dry weight were significantly increased with all concentrations in both seasons. The highest values of the previous characters were obtained by using 150, 200 and 250 ppm. Generally, values

of all treatments were higher than those of control. The stimulatory effect of such treatments on vegetative growth parameters of snap bean plants might be due to the complementarily stimulatory effect of all used antioxidants. Ascorbic acid has effects on many physiological processes including the regulation of growth, differentiation and metabolism of plants (Foyer, 1993). Salicylic acid stimulates the formation of the pentose-phosphate pathway and glucose-6-phosphate (the main product of photosynthesis process) as well as the synthesis of protein (McCue *et al.*, 2000). Citric acid stimulates the absorption of nutrients and hastens growth activators synthesis (Abd El-Naem, 2005). These results agree with those reported by Kato-Naguchi (1997), Fathy and Khedr (2005), Abd El-Allah *et al* (2007), Akram and Hosni (2007), Awad and Mansour, (2007) and Kamel and Abd Al-Gaid (2008).

The interaction effects of both amino acids and antioxidants treatments on vegetative growth characters are illustrated in Tables (1&2). The results show that plant height, leaf area/plant, plant fresh and dry weight were significantly increased in both seasons, except for number of leaves/plant that was significant only in the second season. Foliar application of amino acids at 0.50 mg/l accompanied with antioxidant substances at 150, 200 and 250 ppm exhibited the highest values for all characters in both seasons.

Yield and its components

The effect of amino acids on yield and yield components are presented in Tables (3&4). The obtained results reveal that pods yield (early and total) and its components (number of pods/plant and pod fresh weight) were significantly increased by using amino acids at both concentrations (0.25 and 0.50 mg/l) in both seasons. Pod length was significant only in the first season while dry weight of pod was significant only in the second season. The highest values of all characters were obtained from spraying the mixture of amino acids at 0.50 mg/l (pods total yield was 4.35 and 4.091 ton per fed. in the first and second seasons, respectively). The importance of amino acids came from their widely use for the biosynthesis of a large variety of nonproteinic nitrogenous materials, i.e, pigments, vitamins, coenzymes, purine and purimidine bases (Strove, 1986). These increases might be due to the favorable effects of amino acids on activating of vegetative growth and photosynthetic capacity which was reflected on significant increases on various growth parameters (Tables 1&2). Snap bean plants treated with amino acids resulted in more accumulation of stored food and finally produced good pods yield and yield components. These results are in agreement with those previously obtained by Kamar and Omar (1987) on cucumber and potato, Sharma and Kothari (1993) on mungbean. El-Shabasi *et al* (2005) on garlic, Awad *et al* (2007) on potato and Al-Said and Kamal, (2008) on sweet pepper,

Table (1): Response of snap bean plants to foliar spray with the mixture of antioxidants and amino acids on vegetative growth during 2008 and 2009 seasons.

Treatments	First season 2008				Second season 2009			
	plant height (cm)	No. of leaves / plant	No. of bran-ches/ plant	leaf area/ plant (cm^2)	plant height (cm)	No. of leaves / plant	No. of bran-ches/ plant	leaf area/ plant (cm^2)
Amino acids (Aa) treatments								
Control (tap water)	37.94	13.45	4.57	167.78	34.56	12.85	4.44	155.89
0.25 mg/l	39.55	13.65	4.60	173.41	37.36	13.45	4.59	164.611
0.50 mg/l	41.38	13.77	4.62	176.69	39.06	13.44	4.65	175.78
L.S.D. at 5%	1.69	N.S	N.S	2.51	0.71	0.34	N.S	3.14
Antioxidants (anti) treatments								
Control (tap water)	37.21	12.60	4.50	155.5	34.15	12.49	4.37	150.37
100 ppm	38.76	13.28	4.57	169.46	36.48	12.96	4.54	161.54
150 ppm	40.80	14.00	4.65	178.64	38.14	13.51	4.65	171.53
200 ppm	40.86	14.17	4.63	178.98	38.43	13.68	4.62	171.51
250 ppm	40.50	14.07	4.62	180.54	37.75	13.60	4.62	172.19
L.S.D. at 5%	2.05	0.34	N.S	2.27	1.35	0.41	N.S	3.37
The interactions								
Aa (0) + anti. (0)	34.87	12.34	4.40	150.99	31.87	12.07	4.17	140.62
Aa (0)+anti.(100)	37.03	13.17	4.50	164.37	33.77	12.5	4.37	150.79
Aa (0)+anti.(150)	39.05	13.90	4.67	174.37	35.77	13.1	4.53	159.56
Aa (0)+anti.(200)	39.57	13.97	4.63	175.40	36.07	13.23	4.60	162.83
Aa (0)+anti.(250)	39.17	13.87	4.63	173.75	35.33	13.37	4.53	165.66
Aa (0.25)+anti.(0)	37.3	12.66	4.53	154.85	34.53	12.53	4.40	149.83
Aa.(0.25)+anti.(100)	38.87	13.27	4.60	171.15	36.70	12.97	4.63	160.97
Aa.(0.25)+anti.(150)	40.68	14.10	4.63	178.68	38.23	13.9	4.70	172.15
Aa (0.25)+anti.(200)	40.55	14.14	4.63	180.14	38.63	14.06	4.60	171.01
Aa (0.25)+anti.(250)	40.38	14.10	4.60	182.23	38.70	13.80	4.63	169.09
Aa (0.5)+ anti.(0)	39.46	12.80	4.57	160.66	36.07	12.87	4.53	160.66
Aa (0.5)+anti.(100)	40.37	13.42	4.60	172.85	38.97	13.42	4.63	172.85
Aa (0.5)+anti.(150)	42.66	14.02	4.67	182.88	40.43	13.54	4.73	182.88
Aa (0.5)+anti.(200)	42.45	14.40	4.63	181.41	40.6	13.75	4.67	180.7
Aa (0.5)+anti.(250)	41.96	14.24	4.63	185.64	39.23	13.64	4.70	181.82
L.S.D. at 5%	2.27	N.S	N.S	7.31	3.32	1.17	N.S	4.12

Table (2): Response of snap bean plants to foliar spray with the mixture of antioxidants and amino acids on vegetative growth during 2008 and 2009 seasons.

Treatments	First season 2008			Second season 2009		
	Plant fresh wt.(g)	Plant dry wt.(%)	Stem diameter (cm)	Plant fresh wt.(g)	Plant dry wt.(%)	Stem diameter (cm)
Amino acids (Aa) treatments						
Control (tap water)	61.64	12.08	0.52	58.67	11.96	0.51
0.25 mg/l	63.16	12.14	0.53	61.80	12.04	0.52
0.50 mg/l	64.00	12.14	0.54	63.21	12.09	0.52
L.S.D. at 5%	0.85	N.S	N.S	1.21	0.08	N.S
Antioxidants (anti) treatments						
Control (tap water)	60.25	11.97	0.52	57.33	11.87	0.50
100 ppm	62.03	12.08	0.52	60.23	12.01	0.51
150 ppm	64.11	12.19	0.53	62.66	12.08	0.52
200 ppm	64.20	12.18	0.53	62.74	12.08	0.52
250 ppm	64.08	12.17	0.53	63.17	12.1	0.52
L.S.D. at 5%	1.11	0.14	N.S	2.13	0.11	N.S
The interactions						
Aa (0) + anti.(0)	58.6	11.89	0.51	54.08	11.74	0.5
Aa (0)+anti.(100)	60.54	12.05	0.53	56.5	11.93	0.51
Aa (0)+anti.(150)	62.89	12.11	0.53	60.67	12.05	0.51
Aa (0)+anti.(200)	63.12	12.17	0.53	60.42	12.04	0.52
Aa (0)+anti.(250)	63.06	12.17	0.53	61.67	12.05	0.51
Aa (0.25)+anti.(0)	60.52	11.98	0.52	57.54	11.88	0.51
Aa.(0.25)+anti.(100)	62.46	12.07	0.52	61.36	12.03	0.52
Aa.(0.25)+anti.(150)	64.39	12.25	0.53	63.33	12.07	0.52
Aa (0.25)+anti.(200)	64.44	12.21	0.53	63.16	12.08	0.52
Aa (0.25)+anti.(250)	64.02	12.18	0.53	63.63	12.12	0.51
Aa (0.5)+ anti.(0)	61.62	12.03	0.53	60.38	11.98	0.51
Aa (0.5)+anti.(100)	63.1	12.12	0.53	62.83	12.08	0.51
Aa (0.5)+anti.(150)	65.05	12.2	0.54	63.99	12.12	0.52
Aa (0.5)+anti.(200)	65.04	12.18	0.54	64.65	12.11	0.52
Aa (0.5)+anti.(250)	65.17	12.18	0.55	64.22	12.13	0.53
L.S.D. at 5%	2.21	0.24	N.S	4.12	0.20	N.S

Regarding the effect of antioxidant treatments on yield and yield components, results illustrated in Table (3&4) indicate that foliar application of antioxidant substances was generally more effective than control, as it exerted significant increase on early and total yield and yield components such as number of pods/plant and pod fresh weight. But, pod length was significant only in the first season and dry weight of pod was significant only in the second season. The highest values of all characters were obtained from spraying antioxidants at 150, 200 and 250 ppm. Results could be explained as antioxidants activate plant metabolism and enzymes activity and consequently dry matter accumulation, factors that may positively

reflected on pods yield and its components. Similar interpretation was previously stated by El-Ghamriny *et al* (1999), Moustafa (1999), Nicholas and Wheeler (2000), Abd El-Naem (2005), Fathy and Khedr (2005), Abd El-Allah *et al.*, (2007), Akram and Hosni (2007), Awad and Mansour, (2007), Youssef and Abd-Alla (2007), Kamel and Abd Al-Gaid (2008) and Midan and El-Dinary (2008).

Table (3): Response of snap bean plants to foliar spray with the mixture of antioxidants and amino acids on pods quality during 2008 and 2009 seasons.

Treatments	First season 2008				Second season 2009			
	Pod length (cm)	Pod diameter (cm)	No. of pods/ plant	Pod wt. (g)	Pod length (cm)	Pod diameter (cm)	No. of pods/ plant	Pod wt. (g)
Amino acids (Aa) treatments								
Control (tap water)	12.06	0.65	25.95	3.07	11.75	0.61	24.17	3.04
0.25 mg/l	12.17	0.66	27.45	3.19	11.93	0.62	25.77	3.12
0.50 mg/l	12.23	0.67	28.36	3.33	12.04	0.63	27.71	3.19
L.S.D. at 5%	0.02	N.S	0.63	0.08	N.S	N.S	1.41	0.05
Antioxidants (anti) treatments								
Control (tap water)	11.96	0.62	23.77	3.09	11.73	0.57	22.93	3.03
100 ppm	12.12	0.63	25.51	3.15	11.84	0.61	24.91	3.09
150 ppm	12.22	0.68	28.93	3.25	11.96	0.64	26.87	3.14
200 ppm	12.23	0.67	29.07	3.24	11.98	0.63	27.18	3.15
250 ppm	12.23	0.69	28.98	3.25	12.01	0.64	27.53	3.18
L.S.D. at 5%	0.10	N.S	0.71	0.11	N.S	N.S	1.95	0.06
The interactions								
Aa (0) + anti.(0)	11.82	0.60	22.27	2.98	11.56	0.57	21.16	2.97
Aa (0)+anti.(100)	12.01	0.63	24.17	3.06	11.67	0.60	23.17	3.02
Aa (0)+anti.(150)	12.14	0.67	27.47	3.11	11.82	0.63	25.17	3.06
Aa (0)+anti.(200)	12.16	0.67	27.8	3.10	11.84	0.63	25.30	3.08
Aa (0)+anti.(250)	12.19	0.67	28.03	3.10	11.85	0.60	26.07	3.09
Aa (0.25)+anti.(0)	12.03	0.63	23.8	3.07	11.75	0.57	22.83	3.03
Aa(0.25)+anti.(100)	12.12	0.63	25.9	3.14	11.86	0.60	24.87	3.08
Aa(.25)+anti.(150)	12.21	0.67	29.2	3.25	11.97	0.63	27.03	3.14
Aa(.25)+anti.(200)	12.24	0.67	29.37	3.26	12.00	0.63	27.00	3.15
Aa(.25)+anti.(250)	12.22	0.70	28.97	3.26	12.07	0.67	27.13	3.21
Aa (0.5)+ anti.(0)	12.03	0.63	25.23	3.21	11.89	0.57	24.80	3.11
Aa (0.5)+anti.(100)	12.23	0.63	26.47	3.25	11.99	0.63	26.70	3.16
Aa (0.5)+anti.(150)	12.32	0.70	30.13	3.41	12.09	0.67	28.40	3.22
Aa (0.5)+anti.(200)	12.29	0.67	30.03	3.38	12.10	0.63	29.23	3.23
Aa (0.5)+anti.(250)	12.27	0.70	29.93	3.39	12.13	0.67	29.40	3.24
L.S.D. at 5%	0.139	N.S	3.71	0.15	N.S	N.S	2.25	0.13

Table (4): Response of snap bean plants to foliar spray with the mixture of antioxidants and amino acids on yield pods and its component during 2008 and 2009 seasons.

Treatments	First season 2008			Second season 2009		
	Pod dry wt.(%)	Early yield (ton/fed)	Total yield (ton/fed.)	Pod dry wt.(%)	Early yield (ton/fed)	Total yield (ton/fed)
Amino acids (Aa) treatments						
Control (tap water)	8.41	1.671	4.015	7.96	1.612	3.805
0.25 mg/l	8.46	1.815	4.261	8.06	1.719	4.008
0.50 mg/l	8.47	1.833	4.350	8.17	1.759	4.091
L.S.D. at 5%	N.S	0.032	0.105	0.03	0.051	0.110
Antioxidants (anti) treatments						
Control (tap water)	8.38	1.653	3.993	7.93	1.591	3.810
100 ppm	8.42	1.735	4.125	8.02	1.649	3.900
150 ppm	8.48	1.815	4.299	8.10	1.739	4.019
200 ppm	8.49	1.827	4.287	8.11	1.733	4.035
250 ppm	8.48	1.834	4.339	8.14	1.772	4.075
L.S.D. at 5%	N.S	0.090	0.141	0.08	0.071	0.115
The interactions						
Aa (0) + anti.(0)	8.30	1.503	3.807	7.80	1.483	3.633
Aa (0)+anti.(100)	8.38	1.633	3.953	7.90	1.543	3.710
Aa (0)+anti.(150)	8.45	1.710	4.067	8.00	1.653	3.860
Aa (0)+anti.(200)	8.49	1.740	4.090	8.04	1.653	3.880
Aa (0)+anti.(250)	8.46	1.770	4.157	8.05	1.727	3.940
Aa (.25)+anti.(0)	8.40	1.720	4.013	7.94	1.627	3.857
Aa(.25)+anti.(100)	8.43	1.773	4.160	8.02	1.687	3.940
Aa(.25)+anti.(150)	8.49	1.850	4.370	8.10	1.763	4.060
Aa(.25)+anti.(200)	8.50	1.870	4.360	8.09	1.747	4.077
Aa(.25)+anti.(250)	8.47	1.860	4.403	8.14	1.773	4.107
Aa (0.5)+ anti.(0)	8.44	1.737	4.160	8.06	1.663	3.940
Aa(0.5)+anti.(100)	8.44	1.800	4.263	8.13	1.717	4.050
Aa(0.5)+anti.(150)	8.50	1.887	4.460	8.20	1.800	4.137
Aa(0.5)+anti.(200)	8.48	1.870	4.410	8.21	1.800	4.150
Aa(0.5)+anti.(250)	8.50	1.873	4.457	8.24	1.817	4.180
L.S.D. at 5%	N.S	0.135	0.250	0.25	0.137	0.169

Significant effects for the interactions between amino acids and antioxidants treatment on snap bean yield and its components were noticed in Tables (3&4). The results show that pods yield (early and total) and yield components (number of pods/plant, pod fresh weight) were significantly increased by spraying of amino acids at 0.25 and 0.50 mg/l with antioxidant substances at 150, 200 and 250 ppm, in both seasons. Pod length was significant only in the first season and dry weight of pod was significant only in the second season.

Chemical constituents

Effects of amino acids on nitrogen, phosphorus, potassium and chlorophyll contents of leaves and pods, as well as protein, fiber and total sugar contents of pods in both seasons are shown in Tables (5, 6 &7). The results indicate that spraying of amino acids at 0.25 and 0.50 mg/l significantly increased total chlorophyll contents of leaves and percent of N, P and K of leaves and pods.

Table (5): Response of snap bean plants to foliar spray with the mixture of antioxidants and amino acids on leaves chemical composition during 2008 and 2009 seasons.

Treatments	First season 2008				Second season 2009			
	N (%)	P (%)	K (%)	Total chlorophyll (mg/100g f.w)	N (%)	P (%)	K (%)	Total chlorophyll (mg/100g f.w)
Amino acids (Aa) treatments								
Control (tap water)	3.05	0.477	2.24	265.2	2.79	0.470	2.38	236.6
0.25 mg/l	3.33	0.488	2.37	276.5	2.95	0.480	2.51	253.3
0.50 mg/l	3.54	0.493	2.46	285.1	3.14	0.484	2.58	260.8
L.S.D. at 5%	0.11	0.004	0.09	8.4	0.05	0.002	0.12	7.5
Antioxidants (anti) treatments								
Control (tap water)	3.06	0.475	2.21	260.6	2.78	0.467	2.33	234.5
100 ppm	3.22	0.485	2.30	270.8	2.89	0.475	2.43	244.2
150 ppm	3.37	0.490	2.43	282.0	3.00	0.481	2.55	256.1
200 ppm	3.40	0.489	2.42	281.2	3.02	0.481	2.54	254.6
250 ppm	3.48	0.491	2.42	283.4	3.12	0.485	2.60	261.7
L.S.D. at 5%	0.12	0.005	0.15	9.6	0.08	0.003	0.19	10.2
The interactions								
Aa (0) + anti.(0)	2.73	0.461	2.12	250.3	2.62	0.456	2.21	227.2
Aa (0)+anti.(100)	2.93	0.475	2.24	261.5	2.74	0.464	2.3	233.4
Aa (0)+anti.(150)	3.15	0.482	2.28	271.7	2.83	0.474	2.43	239.1
Aa (0)+anti.(200)	3.20	0.481	2.29	270.4	2.84	0.475	2.43	239
Aa (0)+anti.(250)	3.25	0.489	2.29	272.0	2.93	0.478	2.51	244.4
Aa (0.25)+anti.(0)	3.11	0.476	2.21	260.5	2.79	0.470	2.33	235.9
Aa(0.25)+anti.(100)	3.27	0.490	2.28	271.2	2.89	0.48	2.45	246.5
Aa(0.25)+anti.(150)	3.39	0.492	2.46	284.7	2.98	0.483	2.56	261.4
Aa(0.25)+anti.(200)	3.40	0.492	2.46	283.8	3.02	0.484	2.57	258.3
Aa(0.25)+anti.(250)	3.48	0.491	2.44	282.0	3.09	0.484	2.64	264.3
Aa(0.5)+ anti.(0)	3.35	0.489	2.31	271.0	2.94	0.475	2.44	240.4
Aa (0.5)+anti.(100)	3.47	0.492	2.39	279.6	3.05	0.481	2.53	252.8
Aa (0.5)+anti.(150)	3.59	0.496	2.54	289.5	3.18	0.487	2.65	267.8
Aa (0.5)+anti.(200)	3.59	0.496	2.52	289.4	3.20	0.484	2.63	266.4
Aa (0.5)+anti.(250)	3.72	0.495	2.54	296.1	3.35	0.492	2.66	276.5
L.S.D. at 5%	0.23	0.007	0.20	16.6	0.14	0.009	0.25	19.9

Table (6): Response of snap bean plants to foliar spray with the mixture of antioxidants and amino acids on pod chemical composition during 2008 and 2009 seasons.

Treatments	First season 2008				Second season 2009			
	N (%)	P (%)	K (%)	Protein (%)	N (%)	P (%)	K (%)	Protein (%)
Amino acids (Aa) treatments								
Control (tap water)	2.63	0.417	2.23	17.16	2.48	0.365	2.70	16.15
0.25 mg/l	2.90	0.487	2.37	18.92	2.78	0.411	3.01	18.12
0.50 mg/l	3.00	0.529	2.53	19.57	2.90	0.448	3.23	18.89
L.S.D. at 5%	0.08	0.014	0.02	0.37	0.13	0.021	0.09	0.26
Antioxidants (anti) treatments								
Control (tap water)	2.61	0.417	2.14	16.30	2.44	0.357	2.62	15.25
100 ppm	2.76	0.447	2.3	17.24	2.64	0.388	2.81	16.49
150 ppm	2.91	0.502	2.48	18.19	2.78	0.423	3.18	17.39
200 ppm	2.93	0.504	2.44	18.30	2.80	0.429	3.11	17.48
250 ppm	3.02	0.518	2.51	18.87	2.93	0.444	3.18	18.33
L.S.D. at 5%	0.13	0.015	0.11	0.68	0.14	0.036	0.15	0.41
The interactions								
Aa (0) + anti.(0)	2.41	0.353	2.03	15.06	2.30	0.310	2.37	14.35
Aa (0)+anti.(100)	2.53	0.390	2.13	15.83	2.38	0.343	2.57	14.89
Aa (0)+anti.(150)	2.69	0.440	2.33	16.81	2.51	0.380	2.80	15.71
Aa (0)+anti.(200)	2.73	0.450	2.3	17.06	2.53	0.393	2.83	15.81
Aa (0)+anti.(250)	2.79	0.450	2.33	17.46	2.66	0.400	2.93	16.62
Aa (0.25)+anti.(0)	2.64	0.433	2.13	16.48	2.43	0.363	2.63	15.21
Aa(.25)+anti.(100)	2.82	0.463	2.33	17.62	2.71	0.393	2.83	16.96
Aa(.25)+anti.(150)	2.98	0.513	2.47	18.64	2.86	0.427	3.27	17.85
Aa(.25)+anti.(200)	2.99	0.503	2.43	18.69	2.87	0.433	3.13	17.92
Aa(.25)+anti.(250)	3.08	0.523	2.47	19.27	3.03	0.440	3.17	18.94
Aa (0.5)+ anti.(0)	2.78	0.463	2.27	17.37	2.59	0.397	2.87	16.19
Aa(0.5)+anti.(100)	2.92	0.487	2.43	18.25	2.82	0.427	3.03	17.62
Aa(0.5)+anti.(150)	3.06	0.553	2.63	19.10	2.98	0.463	3.47	18.60
Aa(0.5)+anti.(200)	3.07	0.560	2.60	19.17	2.99	0.460	3.37	18.71
Aa(0.5)+anti.(250)	3.18	0.580	2.73	19.89	3.11	0.493	3.43	19.42
L.S.D. at 5%	0.40	0.024	0.12	1.17	0.36	0.052	0.19	2.27

Table (7): Response of snap bean plants to foliar spray with the mixture of antioxidants and amino acids on pod chemical composition during 2008 and 2009 seasons.

Treatments	First season 2008			Second season 2009		
	Total chlorophyll (mg/100g f.w)	Fiber content (%)	Total sugar content (%)	Total Chlorophyll (mg/100g f.w)	Fiber content (%)	Total sugar content (%)
Amino acids (Aa) treatments						
Control (tap water)	0.419	8.29	10.99	0.390	8.79	11.69
0.25 mg/l	0.436	8.28	11.25	0.405	8.74	11.87
0.50 mg/l	0.458	8.24	11.39	0.417	8.68	12.00
L.S.D. at 5%	0.090	N.S	0.04	N.S	N.S	0.12
Antioxidants (anti) treatments						
Control (tap water)	0.414	8.30	10.99	0.384	8.80	11.63
100 ppm	0.428	8.28	11.14	0.396	8.77	11.73
150 ppm	0.449	8.26	11.25	0.412	8.71	11.95
200 ppm	0.446	8.26	11.30	0.410	8.72	11.96
250 ppm	0.451	8.25	11.36	0.416	8.68	12.00
L.S.D. at 5%	0.11	N.S	0.05	N.S	N.S	0.19
The interactions						
Aa (0)+ anti. (0)	0.404	8.33	10.87	0.370	8.86	11.49
Aa (0)+anti.(100)	0.417	8.30	11.01	0.380	8.82	11.62
Aa (0)+anti.(150)	0.428	8.29	10.75	0.399	8.76	11.78
Aa (0)+anti.(200)	0.424	8.28	11.14	0.396	8.76	11.75
Aa (0)+anti.(250)	0.425	8.28	11.16	0.404	8.74	11.79
Aa (0.25)+anti.(0)	0.414	8.31	10.99	0.383	8.79	11.64
Aa (.25)+anti.(100)	0.425	8.27	11.17	0.399	8.76	11.71
Aa (.25)+anti.(150)	0.448	8.27	11.46	0.415	8.72	11.93
Aa (.25)+anti.(200)	0.444	8.28	11.28	0.412	8.73	12.03
Aa (.25)+anti.(250)	0.451	8.25	11.34	0.415	8.71	12.06
Aa (0.5)+ anti.(0)	0.425	8.28	11.11	0.400	8.74	11.75
Aa (0.5)+anti.(100)	0.442	8.26	11.25	0.408	8.72	11.85
Aa (0.5)+anti.(150)	0.472	8.23	11.55	0.425	8.65	12.14
Aa (0.5)+anti.(200)	0.470	8.23	11.47	0.422	8.66	12.10
Aa (0.5)+anti.(250)	0.477	8.22	11.58	0.429	8.61	12.16
L.S.D. at 5%	0.25	N.S	0.15	N.S	N.S	0.21

Also, protein and total sugar contents of pods in both seasons were increased. Total chlorophyll content of pods was significant only in the first season. The highest values were detected in plants sprayed with the mixture of amino acids. Such improvement could be reflected on the increase in dry matter accumulation through the improvement of photosynthetic production. These results are in line with those obtained by Gamal El-Din *et al* (1997), El-Shabasi *et al* (2005), , Awad *et al* (2007) and Al-Said and Kamal (2008).

Results of the chemical analysis reflected significant differences among the antioxidant treatments in both seasons (Tables 5, 6 &7). Total chlorophyll

contents, N, P and K percentage of leaves and pods, also protein and total sugar contents of pods were increased with spraying phaseolus plants with of antioxidant substances at 150, 200 and 250 ppm. These results are in accordance with those reported by Awad and Mansour, (2007), El-Ghamriny *et al* (1999), Moustafa (1999), Youssef and Abd-Alla (2007) and Kamel and Abd Al-Gaid (2008), The interactions between application of both amino acids and antioxidants significantly affected total chlorophyll contents of leaves, N, P and K percentage of leaves and pods as well as protein and total sugar contents of pods, in both seasons except for total chlorophyll content of pods that was significantly only in the first season. Foliar application of amino acids at 0.50 mg/l and antioxidant substances at 150, 200 and 250 ppm showed the highest values of all characters, in both seasons. Generally, values of all treatments were higher than those of the control (Tables 5, 6 &7).

CONCLUSION

In general, foliar application of amino acids at 0.50 mg/l with spraying of antioxidant substances (mixture of vitamin C, salicylic acid and citric acid) at 150, 200 and 250 can be recommended for improving growth, yield and yield components of snap bean under the conditions of the experiment, as indicated in this work.

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تحسين إنتاجية وجودة نباتات الفاصوليا باستخدام الرش بالأحماض الأمينية وبعض مضادات الأكسدة.

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الملخص العربي

أجريت هذه الدراسة خلال موسمين زراعيين صيفيين متتالين هما ٢٠٠٨ و٢٠٠٩ بالمزرعة البحثية بكلية الزراعة – جامعة طنطا –طنطا –مصر واستخدم فيها صنف الفاصوليا بوليستا لدراسة تأثير الرش بالأحماض الأمينية بتركيزات ٠,٢٥ و ٠,٥ مجم /لتر(بعد ١٥ و٣٠ و٤٥ و٦٠ و٧٥ يوم من الزراعة) وكذلك تأثير الرش ببعض مضادات الأكسدة من خليط من فيتامين c وحمض السالسيليك وحمض الستريك) بتركيزات ١٠٠ و١٥٠ و٢٠٠ و٢٥٠ جزء فى المليون (بعد ٢١ و٣٥ و٤٩ و٦٣ يوم من الزراعة) على إنتاجية وجودة الفاصوليا وقد وزعت المعاملات في قطع منشقة مرة واحدة في ثلاثة مكررات. ويمكن تلخيص النتائج المتحصل عليها فيما يلي :-

رش نباتات الفاصوليا بالأحماض الأمينية بتركيز ٠,٥ مجم /لتر قد حسنت صفات النمو الخضري (ارتفاع النبات والمساحة الورقية والوزن الطازج والجاف للنبات) وكذلك أعطت أعلى قيمة لمحصول القرون الخضراء المبكر والكلى وعدد القرون لكل نبات وطول القرن والوزن الطازج والجاف للقرون وكذلك المحتوى الكيماوي للقرون والأوراق من العناصر التي تم دراستها.

أعطى الرش بعض مضادات الأكسدة بتركيزات ١٥٠ و٢٠٠ و٢٥٠ جزء في المليون أعلى قيمة لصفات النمو ومحصول القرون الطازجة وعدد القرون لكل نبات وطول القرن والوزن الطازج والجاف للقرون وكذلك المحتوى الكيماوي للقرون والأوراق.

لوحظ أن جميع التركيزات المستخدمة للعاملين تحت الدراسة قد أعطت نتائج أعلى من الكنترول وكذلك كانت النتائج معنوية.

عموماً، يمكن التوصية برش نباتات الفاصوليا بالأحماض الامينية بتركيز ٠,٥ مجم /لتر وكذلك الرش بمضادات الأكسدة بتركيزات ١٥٠ أو ٢٠٠ أو ٢٥٠ جزء في المليون لتحسين نمو وزيادة إنتاج وجودة القرون الخضراء للفاصوليا تحت ظروف الأراضي الطينية.