IMPACT OF SOME ANTIOXIDANTS ON GROWTH AND PRODUCTIVITY OF TWO SNAP BEAN CULTIVARS UNDER FAYOUM CONDITIONS

Mofreh, S. Tolba
Horticulture Department, Faculty of Agriculture, Fayoum University, Fayoum, Egypt

ABSTRACT

Poulista and Xera are the most important snap bean cultivars growing under El- Fayoum conditions, for both local market and export. Antioxidant substances are organic compounds, i.e., organic acid or hormones. Recent studies concentrated on the beneficial effects of these antioxidant substances to improve plants performance. Therefore, an experiment was carried out during the fall seasons of 2016 and 2017 in a private farm at El-Fayoum Governorate, Egypt to study the effect of 7 antioxidant substances, i.e., indole -3- acetic acid, indole -3- butyric acid, ascorbic acid, citric acid, salicylic acid, tartaric acid and oxalic acid as a foliar application, each at the rate of 500 ppm, on growth characters, green pods yield and pod qualities of Poulista and Xera plants. Seeds of both cultivars were sown in September; experimental design was spilt plot. Antioxidant applications were done after 20, 30 and 40 days from planting and plant samples were taken after 50 and 70 days for growth characters and for green pods yield and quality parameters, respectively. Results showed that Xera variety was the higher in pod length, pods weight/ plant^{-1}, chlorophyll a, b and total chlorophyll content in leaves and amino acid content in pods compared with Poulista variety. Moreover, Poulista variety was higher in plant height, carbohydrates content in stem and pods and amino acid content in stem compared with Xera cultivar.

All foliar antioxidant applications significantly increased all growth characters, pods yield and pod quality and chemical composition of carotenoids, chlorophyll a, b and total chlorophyll, as well as, carbohydrates and amino acid contents in leaves, stem and pods of snap bean plants compared with the control treatment. The superior application was oxalic acid followed by ascorbic acid, respectively, while citric acid gave the highest content of amino acid in stem. The remarkable growth and production improvement in Xera or Poulista cultivar obtained when plants treated with oxalic or ascorbic acid 3 times (20, 30, 40 days) from planting at the concentration of 500 ppm.

***Key words**: antioxidant, snap bean, poulista, xera, growth, production*

INTRODUCTION

Phaseolus vulgaris L. is a member of *Fabaceae* family. It is known as snap, common or kidney beans. The most cultivars grown in Egypt are bush varieties type, that have a short growing period. Snap bean is one of the most important vegetable crops cultivated in Egypt either for local market or export, and it considered as important source of carbohydrates, protein, vitamins and minerals (Abdel-Hakim, et al., 2012). Egypt has a potential to be a large-scale producer and exporter, therefore, cultivation the right cultivars; i.e. Poulista or Xera is the first step for this aim because yield and quality of snap bean are greatly affected by genotype of the variety (Nassar, 1986 and Amer et al., 2002). Improving the production and quality of bean green pods not only depends on genotype effect but also on environmental conditions and all agro-management practices. Hence, this improving could be achieved through using the foliar application of antioxidant substances.

Antioxidants are the substances that when present in low concentration effectively protect the cell membrane against the damage induced by oxidation processes. These antioxidants include compounds of enzymatic or a non-enzymatic nature (Halliwell and Gutteridge. 1989). Oxidation is a chemical reaction that can produce free radicals. They are atoms, molecules or ions with unpaired electrons (O^{2-}, superoxide radicals; OH^-, hydroxyl radical; HO_2, perhydroxy radical and RO^-, alkoxy radicals), which are highly reactive to chemical reactions with other molecules. These free radicals are part of groups of molecules called reactive oxygen species (ROS), that are occur in tissues and cells and can damage DNA, proteins, carbohydrates and lipids (Vajragupta *et al.,* 2004 and Govindaraj et al., 2017). Under normal conditions, ROS are generated during photosynthesis by singlet oxygen formation as well as oxygen photoreduction. Photooxidative damage can occur when ROS production exceeds that of the antioxidant capacity (Conklin, 2001), whereas Dat et al. (2000) suggested that ROS are generated in response to stress condition. Plants with high level of antioxidants have greater resistance to oxidative damage in plant cells by eliminating lipid and protein peroxidation (Younis et al., 2010).

Indol- acetic acid and indol butyric acid are auxins, that are a class of phytohormones which are involved in many aspects of growth and development of plants (Davies, 1995). Ascorbic acid, citric acid, salicylic acid, tartaric acid and oxalic acid are organic compounds that occur naturally in plants and contributed in the several photosynthesis and physiological processes in plants

Several studies have been conducted to evaluate the response of snap bean plants to foliar spraying of antioxidants. Nour et al. (2012) found that, plant growth, yield and its components and chemical constituents of pods were significantly affected by treating snap bean plants with different antioxidant materials. Application of acetylsalicylic acid (ASA) and indole-3-butyric acid (IBA) as a foliar spraying on pea plants enhanced plant growth, yield and pods quality. These positive effects of ASA and IBA were correlated with significant increase in total chlorophylls in leaves, total soluble proteins, praline, phenol, total soluble carbohydrates and sugars in seeds (El- Shraiy and Hegazi, 2009). Using 100 ppm of Salicylic acid and 150 ppm of vitamin E as a foliar application gave the highest increment in plant length, number of leaves and branches, canopy dry weight, total green pods yield and its components and seeds quality of snap bean plants (Shafeek et al., 2014). Thomson, et al. (2017)

found that spraying garden pea plants by ascorbic acid at 200 ppm gave the best results for total yield and pod thickness. High positive improving in growth characters, seed yield, seed oil %, seed protein % and plant pigments were recorded by treating sunflower plants with citric acid and ascorbic acid (El Mantawy, 2017). Foliar application of humic acid and oxalic acid on wheat plants leads to significant increases in the yield and enhancing plant performance (El-Shabrawi et al., 2015). Sadak and Orabi (2015) reported that, citric acid or oxalic acid treatment, each at the concentrations 100 and 200 ppm showed marked increases in growth parameters and yield value of wheat plants. Ofir et al. (1993) found a strong relation between pods yield in green bean and the level of auxin Indole-acetic acid in the flower or pods.

This study aimed to use some antioxidant substances to improve growth, yield and quality of snap bean varieties grown under El-Fayoum Governorate conditions.

Materials and methods

Two field trails were conducted during the two successive fall seasons of 2016 and 2017, to study the effect of foliar application of some antioxidants; indole -3- acetic acid, indole -3- butyric acid, ascorbic acid, citric acid, salicylic acid, tartaric acid and oxalic acid, each at the concentration of 500 ppm, on the growth, production and chemical composition of two snap bean cultivars (Poulista and xera). The experiments were carried out in a private farm at El wanaysa, Itsa, El-Fayoum Governorate, Egypt. Before the conduction of experiment, random soil samples were taken at the depth of 30cm for physical and chemical analysis as shown in Table (1) according to the method described by Jakson (1973).

Seeds were sown at the first week of September in both seasons on rows and thinned on two plants/hill after germination. The raw was 5 m length, 65 cm width and 20 cm apart. The experimental unit consists of 4 rows and covered an area of 13 m^2.

Experimental layout was split plot system in a randomized complete blocks design with three replicates. Bean cultivars were randomly allocated in the main plots, while the foliar antioxidant applications were randomly arranged in the sub plots. All recommended agro-managements for commercial production of bean were achieved.

Antioxidants were applied three times. The first one was after 20 days from seed sowing, while the remainder two applications were after 30 and 40 days, respectively.

Table1. Some physical and chemical characteristics of the experimental site.

Properties	value
Physical properties	
Clay (%)	20.46
Silt (%)	34.31
Fine sand (%)	32.45
Soil texture	Loamy
Chemical properties	
pH	7.10
ECe (dsm^{-1})	1.95
Organic matter (%)	1.95
Ca CO_3 (%)	4.90
N (%)	0.19
P (%)	0.30
K (%)	0.32
Soluble ions (mg/ 100 g soil)	
Ca^{++}	4.67
Mg^{++}	11.35
Na^{+}	3.83
K^{+}	0.75
CO_3^{--}	0.00
HCO_3^{-}	6.19
Cl^{-}	7.47
SO_4^{--}	5.84

Recorded data:

Vegetative growth:

Tweenty plants were randomly taken from the first row of each experimental unit and cut off after 50 days from seed sowing date and the following plant growth parameters were recorded; plant height and number of branches.

Pods yield and pod quality:

Along harvest stage of bean green pods, 20 plants randomly chosen from second and third row of each plot and their pods were collected for the following pods quality and yield measurements; number of pods/plant, pod length, pod diameter and pods weight/ $plant^{-1}$.

Chemical composition:

At harvest stage of green pods, 20 plants were collected from the fourth row and the plants were separated into leaves, stems and pods to estimate the following chemical compositions:

- Chlorophyll and carotenoid contents according to Cherry (1973).
- Total carbohydrates were determined calorimetrically according to the method described by Dubois et al. (1956).
- Total free amino acids as descripted by Dubois et al. (1956).

Results and discussion

1- Growth characters

The effect of snap bean cultivars and foliar antioxidant applications, as well as, their interaction on the plant height and number of branches in the two growing seasons of 2016 and 2017 are presented in Table (2).

The values of plant height and number of branches did not reflect any significant differences between the two studied cultivars (Xera and Poulista) in both seasons, except plant height in the second season, Poulista recorded the higher significant value of plant height compared with Xera.

The obtained results in Table (2) indicated that all foliar antioxidants application significantly increased plant height and number of branches compared with untreated plants in both seasons. Spraying snap bean plants with oxalic acid or ascorbic acid gave the highest significant values of plant height and number of branches in both seasons, moreover the lowest significant values of studied growth characters were recorded from control plants in both seasons.

Oxalic acid is one of the strongest organic acids in plants (Lane, 1994), and ascorbic acid is an abundant component in plants (Smirnof and Wheeler, 2000). The beneficial effect of ascorbic acid on plant growth may be explain on the ground of that ascorbic acid is involved in the regulation of cell vaculation and cell expansion (Smirnoff, 1996). Moreover, it is increases the content of Indole - acetic acid, which stimulates cell division and cell enlargement, therefor improves plant growth (Khan et al., 2011). These results are agreement with those recorded by El Mantawy (2017), Sadak and Orabi (2015) and El-Shabrawi et al. (2015) for oxalic acid on wheat.

All combinations between cultivars and foliar antioxidants spraying recorded significant differences in growth characters expressed as (plant height and number of branches), except number of branches in the first season. The highest values of plant height were recorded by treating Poulista with oxalic acid followed by Poulista with ascorbic acid in both seasons. Meanwhile spraying Poulista plants with oxalic acid followed by Poulista with ascorbic acid gave the best recorded of number of branches in the second season. Treating Xera plants with ascorbic acid produced highest number of branches in second season. Untreated plants of Poulista or Xera recorded the lowest values of plant height and number of branches in both seasons.

Table2: Effect of cultivars and foliar spraying of different antioxidant substances on growth characters of snap bean plants during 2016 and 2017 seasons.

Treatments		Plant height (cm)		No. of branches	
cultivars	**Treatment**	**2016**	**2017**	**2016**	**2017**
Xera	**Main**	37.4	36.7	8.5	8.5
Poulista	**effect**	39.4	39.2	9.1	8.8
Main effect	**Control**	26.0	21.7	6.5	5.8
	Indole acetic	37.5	38.8	7.6	7.5
	Indole butyric	39.1	39.6	8.8	8.5
	Salicylic	37.0	37.5	8.6	9.5
	Ascorbic	43.2	43.4	10.2	10.0
	Oxalic	46.0	44.9	11.0	10.0
	Tartaric	39.3	39.2	9.2	8.9
	Citric	39.0	38.6	8.7	9.1
Xera	**Control**	25.3	21.3	5.7	5.7
	Indole acetic	37.0	37.3	8.0	8.0
	Indole butyric	39.3	39.1	8.7	8.0
	Salicylic	37.0	37.0	8.3	9.0
	Ascorbic	40.8	40.8	10.0	10.0
	Oxalic	41.3	40.6	10.0	9.0
	Tartaric	38.3	38.7	9.0	9.0
	Citric	40.0	39.0	8.3	9.7
Poulista	**Control**	26.7	22.0	7.4	6.0
	Indole acetic	37.9	40.3	7.1	7.1
	Indole butyric	38.8	40.0	9.0	8.9
	Salicylic	37.0	38.0	8.8	10.0
	Ascorbic	45.7	46.0	10.3	10.0
	Oxalic	50.7	49.2	12.0	11.0
	Tartaric	40.3	39.7	9.4	8.8
	Citric	37.9	38.2	9.1	8.5
LSD5%					
cultivars		n.s.	n.s.	n.s.	n.s.
Treatment		2.4	1.0	1.1	1.0
Interaction		3.4	1.8	n.s.	n.s.

2- Pods yield and pod quality:

Data illustrated in Table (3) show the main and interaction effects of two snap bean cultivars and various antioxidant applications on number of pods, pod length, pods weight/plant^{-1} and pod diameter in the two growing seasons of 2016 and 2017.

The effect of cultivars on number of pods and pod diameter was not significant in the two seasons, while the results of pod length and pods weight/ plant^{-1} clearly showed significant differences between Xera and Poulista varieties in this respect during the two seasons. Xera recorded the higher values of pod length and pods weight/ plant^{-1} compared with Poulista in the two seasons.

The variance between cultivars can be explained on the basis that, yield and quality of snap bean are affected by genotype of the variety (Nassar, 1986 and Amer et al., 2002). The same results were reported by Abdel-Mawgoud et al. (2005) and Brunner et al. (2014).

All foliar antioxidant treatments significantly improved all studied parameters of pods yield and pod quality compared with untreated plants. Plants treated with oxalic acid or ascorbic acid produced the highest values of number of pods, pod length, pods weight/ $plant^{-1}$ and pod diameter in the two growing seasons, whereas the lowest values of the previous studied parameters were recorded in untreated plants during the two seasons.

It has been known that oxalic acid acts as enzyme cofactor, i.e., hydrolase enzyme, electron transport, oxalate and tartrate synthesis (Mehdy 1994). Smirnof and Wheeler (2000) also, cleared that ascorbic acid functions as an antioxidant and an enzyme cofactor. The role of ascorbic acid in enhancing pods yield and pod quality parameters can be explained on the basis that ascorbic acid increased the assimilates transported to the reproductive organs in plants, therefor more number and heavier weight of green pods $plant^{-1}$ may arise (Mervat et al. 2010). These results are in agreement with those reported by Barakat et al. (2015) on common bean, El-Hendaway et al. (2011) on faba bean, Sadak and Orabi (2015) and El-Shabrawi et al. (2015) on wheat for oxalic acid and Thomson et al. (2017) on garden pea.

The comparisons among the values of number of pods, pod length, pods weight/ plant and pod diameter showed that the combinations between snap bean cultivars (Poulista and Xera) and all foliar antioxidant treatments were significantly differed in the two seasons. Either Poulista or Xera plants treated with oxalic acid or ascorbic acid gave the high significant values of number of pods, pod length, pods weight/ $plant^{-1}$ and pod diameter, while the lowest values of aforementioned parameters were obtained in Xera or Poulista plants with control in both seasons.

Table3: Effect of cultivars and foliar spraying of different antioxidant substances on pods yield and pod quality of snap bean plants during 2016 and 2017 seasons.

Treatments		No. of pods		Pod length (cm)		Pods weight/ plant (g)		Pod diameter (cm)	
cultivars	Treatment	2016	2017	2016	2017	2016	2017	2016	2017
Xera	Main	20.4	19.6	16.9	16.9	128.0	126.8	0.73	0.73
Poulista	effect	20.3	20.3	15.3	15.2	114.6	114.4	0.73	0.74
Main effect	Control	15.4	15.3	12.7	13.6	68.0	68.1	0.56	0.55
	Indole acetic	20.1	20.4	15.7	15.9	109.1	114.7	0.71	0.71
	Indole butyric	20.5	20.4	16.3	16.3	116.3	118.6	0.77	0.73
	Salicylic	20.1	19.1	15.4	16.0	113.8	111.6	0.74	0.71
	Ascorbic	23.1	22.9	17.8	17.5	158.8	159.2	0.86	0.87
	Oxalic	23.1	23.5	18.4	17.8	154.3	164.3	0.80	0.84
	Tartaric	21.4	19.0	16.6	16.0	142.8	119.2	0.69	0.71
	Citric	19.2	19.0	15.8	15.7	107.2	109.3	0.71	0.76
Xera	Control	15.5	14.7	13.9	14.9	69.9	69.0	0.58	0.55
	Indole acetic	19.3	19.3	16.8	16.8	116.3	123.0	0.64	0.72
	Indole butyric	20.7	20.0	17.3	17.1	129.5	129.9	0.78	0.71
	Salicylic	20.0	19.0	16.8	17.0	112.6	116.2	0.73	0.70
	Ascorbic	23.0	23.0	18.3	18.3	163.0	163.4	0.88	0.88
	Oxalic	23.7	23.0	18.3	18.1	159.4	163.9	0.80	0.84
	Tartaric	22.0	18.3	17.5	17.0	151.2	117.2	0.69	0.67
	Citric	19.0	19.7	16.3	16.3	122.5	131.8	0.71	0.77
Poulisa	Control	15.2	16.0	11.5	12.2	66.2	67.2	0.54	0.56
	Indole acetic	20.9	21.5	14.5	14.9	101.9	106.4	0.78	0.70
	Indole butyric	20.4	20.7	15.3	15.5	103.1	107.4	0.75	0.75
	Salicylic	20.3	19.1	14.1	14.9	115.1	106.9	0.75	0.71
	Ascorbic	23.1	22.8	17.3	16.8	154.7	154.9	0.84	0.86
	Oxalic	22.6	24.0	18.5	17.4	149.1	164.7	0.80	0.85
	Tartaric	20.8	19.6	15.7	15.0	134.4	121.1	0.69	0.75
	Citric	19.4	18.3	15.3	15.0	92.0	86.8	0.70	0.75
LSD5%									
cultivars		n.s.	n.s.	1.2	0.5	8.0	8.4	n.s.	n.s.
Treatment		1.0	1.1	1.1	0.8	11.5	9.7	0.06	0.06
Interaction		n.s.	n.s.	1.6	1.0	16.2	13.8	n.s.	n.s.

3- chemical compositions:

3-1- photosynthetic pigments content in leaves (Carotenoids and chlorophyll a, b and total chlorophyll (a+b):

Table (4) shows the influences of two snap bean cultivars, various antioxidant applications and interaction between cultivars and antioxidants on content of carotenoids and chlorophyll a, b and total chlorophyll (a+b) in leaves of snap bean plants in the two growing seasons of 2016 and 2017.

The values of carotenoids content in leaves did not reflect any significant differences between Poulista and Xera plants in both seasons, whereas the effect of cultivars on chlorophyll a, b and total chlorophyll content were significant in both seasons. Xera registered the higher amount of chlorophyll a, b and total chlorophyll (a+b) compared with Poulista in both seasons.

The data obtained in table (4) indicated that spraying snap bean plants with the antioxidant substances produced significant increases in carotenoids and chlorophyll a, b and total chlorophyll (a+b) content in leaves compared with the control plants in both seasons. Oxalic acid or ascorbic acid treatments gave the highest values of the aforementioned parameters, while the lowest values were recorded in the untreated plants in both seasons.

The results also revealed that all combinations between studied cultivars and antioxidant applications were significantly increased the contents of carotenoids and chlorophyll a, b and total chlorophyll (a+b) in leaves of snap bean plants compared with untreated Xera or poulista plants in both seasons. The combination of oxalic acid or ascorbic acid applications with Xera or Poulista plants recorded the highest values of all Photosynthetic pigments content in leaves, while the lowest values obtained in untreated Xera or Poulista plants in both seasons.

Table 4: Effect of cultivars and foliar spraying of different antioxidant substances on carotenoids and chlorophyll a, b and total chlorophyll (a+b) contents (mg/g^{-1} F.W.) in leaves of snap bean plants during 2016 and 2017 seasons.

Treatment		Carotenoids		Total chlorophyll(a+b)		Chlorophyll a		chlorophyll b	
cultivars	**treatments**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Xera	**Main**	1.23	1.23	4.94	4.92	2.50	2.47	2.44	2.45
Poulista	**effect**	1.24	1.24	3.72	3.70	2.05	2.04	1.67	1.66
Main effect	**Control**	0.74	0.77	3.68	3.69	2.02	2.01	1.65	1.68
	Indole acetic	0.97	0.96	3.87	3.88	2.12	2.11	1.75	1.78
	Indole butyric	1.45	1.43	4.07	4.06	2.17	2.14	1.90	1.93
	Salicylic	1.25	1.28	4.37	4.35	2.28	2.28	2.10	2.07
	Ascorbic	1.60	1.63	5.20	5.22	2.65	2.64	2.55	2.58
	Oxalic	1.71	1.69	5.24	5.19	2.68	2.66	2.57	2.53
	Tartaric	1.14	1.14	4.03	4.01	2.11	2.08	1.92	1.94
	Citric	1.01	1.01	4.17	4.11	2.17	2.15	2.01	1.96
Xera	**Control**	0.67	0.68	4.55	4.55	2.35	2.30	2.20	2.25
	Indole acetic	0.87	0.88	4.71	4.71	2.41	2.37	2.30	2.35
	Indole butyric	1.30	1.25	4.83	4.85	2.43	2.40	2.40	2.45
	Salicylic	1.27	1.35	4.83	4.82	2.45	2.45	2.38	2.37
	Ascorbic	1.70	1.70	5.45	5.43	2.68	2.67	2.77	2.75
	Oxalic	1.72	1.73	5.63	5.55	2.83	2.80	2.80	2.75
	Tartaric	1.30	1.30	4.73	4.72	2.38	2.35	2.35	2.37
	Citric	0.98	0.97	4.80	4.75	2.47	2.45	2.33	2.30
Poulista	**Control**	0.81	0.85	2.80	2.82	1.70	1.72	1.11	1.10
	Indole acetic	1.07	1.05	3.03	3.05	1.83	1.85	1.20	1.20
	Indole butyric	1.60	1.60	3.30	3.27	1.90	1.88	1.40	1.40
	Salicylic	1.23	1.20	3.92	3.88	2.10	2.10	1.82	1.77
	Ascorbic	1.50	1.55	4.95	5.00	2.62	2.60	2.33	2.40
	Oxalic	1.70	1.65	4.85	4.83	2.52	2.52	2.33	2.30
	Tartaric	0.98	0.98	3.33	3.30	1.83	1.80	1.50	1.50
	Citric	1.03	1.05	3.55	3.47	1.87	1.85	1.68	1.62
LSD5%									
cultivars		n.s.	n.s.	0.07	0.06	0.12	0.07	0.15	0.13
Treatment		0.09	0.05	0.16	0.15	0.07	0.05	0.14	0.11
Interaction		0..13	0..08	0.23	0.21	0.09	0.08	0.20	0.16

The increase in photosynthetic pigments content in leaves may be due to the role of antioxidants in protecting chloroplast from oxidative damage (Sahu et al. 1993) and also enhancing the accumulation of chlorophyll and delay senescence (Mattagajasingh and Kar, 1989 and Novabour et al., 2003). These results are agreement with those obtained by El Shiekh et al. (2014) on faba bean and Salama et al. (2014) on bean. They reported that ascorbic acid application increased carotenoids and chlorophyll a, b and total chlorophyll (a+b) compared with the untreated plants.

3-2- Content of carbohydrates and amino acids in leaves, stem and pods of snap bean plants.

The effects of cultivars, antioxidants application and their interaction on content of carbohydrates and amino acid in leaves, stem and pods of snap bean plants during the seasons of 2016 and 2017 are illustrated in Tables (5, 6).

Content of carbohydrates:

The effect of cultivars on content of carbohydrates was not significant in leaves, while was significant in stem during the two seasons. In pods, the effect of cultivars on carbohydrates content was significant in the second season only. The higher amount of carbohydrates in stem recorded in Poulista than in Xera plants in both seasons, whereas in pods the higher amount of carbohydrates were recorded in Poulista plants in the second season only (table 5).

Data recorded in Table (5) showed that all antioxidant spraying produced significant increases in carbohydrates contents in leaves, stem and pods in both seasons. Oxalic acid or ascorbic acid treatments gave the highest values of carbohydrates content in leaves, stem and pods, while the lowest values were recorded in untreated plants in both seasons.

The interaction between snap bean cultivars and antioxidant applications significantly increased the contents of carbohydrates in leaves, stem and pods compared with control plants in both seasons (table 5).

The combination of oxalic acid or ascorbic acid with Xera variety gave the highest values of carbohydrates content in leaves in both years. In stem, the combination of Oxalic acid or tartaric acid with Poulista produced the highest amount of carbohydrates content in both seasons, while in pods, the highest values of carbohydrates content were recorded when Poulista plants treated with ascorbic or oxalic acid in both seasons. The lowest amount of carbohydrates content in leaves, stem and pod were collected in untreated plants either for Xera or Poulista in both seasons.

Table 5: Effect of cultivars and foliar spraying of different antioxidant substances on carbohydrates content (mg/g^{-1} D.W.) in leaves, stem and pods of snap bean plants during 2016 and 2017 seasons.

Treatments		Total carbohydrates leaves		Total carbohydrates stem		Total carbohydrates pods	
cultivars	Treatment	2016	2017	2016	2017	2016	2017
Xera	Main	1.94	1.94	1.36	1.44	2.29	2.35
Poulista	effect	1.97	1.95	1.75	1.70	2.50	2.45
Main effect	Control	1.55	1.58	1.13	1.28	1.93	2.03
	Indole acetic	1.81	1.76	1.11	1.22	2.28	2.25
	Indole butyric	1.83	1.79	1.40	1.43	2.28	2.35
	Salicylic	1.96	1.96	1.47	1.53	2.45	2.48
	Ascorbic	2.17	2.18	1.78	1.76	2.80	2.73
	Oxalic	2.21	2.18	1.93	1.83	2.90	2.84
	Tartaric	2.03	2.12	1.82	1.77	2.22	2.25
	Citric	2.09	2.00	1.77	1.74	2.30	2.27
Xera	Control	1.50	1.57	0.87	1.23	1.90	1.93
	Indole acetic	1.73	1.72	1.20	1.23	2.17	2.20
	Indole butyric	1.73	1.72	1.30	1.37	2.15	2.27
	Salicylic	1.83	1.92	1.20	1.27	2.30	2.43
	Ascorbic	2.30	2.23	1.50	1.65	2.60	2.63
	Oxalic	2.30	2.27	1.70	1.70	2.83	2.83
	Tartaric	2.03	2.13	1.50	1.47	2.10	2.23
	Citric	2.07	1.97	1.60	1.57	2.23	2.23
Poulista	Control	1.60	1.60	1.40	1.32	1.97	2.13
	Indole acetic	1.88	1.80	1.03	1.20	2.38	2.30
	Indole butyric	1.93	1.86	1.50	1.50	2.40	2.43
	Salicylic	2.09	2.00	1.73	1.78	2.60	2.53
	Ascorbic	2.03	2.12	2.07	1.87	3.00	2.82
	Oxalic	2.13	2.10	2.17	1.97	2.97	2.85
	Tartaric	2.03	2.11	2.13	2.07	2.33	2.27
	Citric	2.12	2.03	1.93	1.92	2.37	2.30
LSD5%							
cultivars		n.s.	n.s.	0.10	0.03	n.s.	n.s.
Treatment		0.13	0.15	0.11	0.12	0.14	0.15
Interaction		0.18	0.21	0.15	0.16	n.s.	n.s.

Content of amino acids:

Xera and Poulista plants did not differ significantly in respect to the content of amino acids in leaves in both seasons, moreover, in stem and pods the values of amino acids content were affected significantly by the type of snap bean cultivar. In stem, the higher amount of amino acids content recorded in Poulista plants in both seasons, whereas in pods the higher amount of amino acid were obtained in Xera plants during the two seasons of 2016 and 2017 (table 6).

All antioxidant treatments significantly increased the content of amino acids in leaves, stem and pods compared with the untreated snap bean plants in both seasons. In leaves, the highest values of amino acids content obtained in the plants treated with oxalic acid or citric acid in both seasons. Citric acid application recorded the highest content of amino acids in stem in both seasons. In pods, the highest value of amino acids was registered in the plants treated with oxalic acid in both seasons, whereas the lowest values of amino acids content in leaves, stem and pods were found in untreated plants in both seasons (table 6).

The interaction between snap bean cultivars and foliar antioxidant applications recorded significant differences in the Contents of amino acids in leaves, stem and pods in both seasons. In leaves, treating Xera plants with citric acid gave the highest content of amino acid in the first season, meanwhile spraying Poulista or Xera plants with oxalic acid produced the highest content of amino acids in the second season. In stem, citric acid with Xera plants or citric acid with Poulista plants registered the highest values of amino acids content in both seasons. Treating Xera or Poulista plants with oxalic acid produced the highest record of amino acids content in pods during the two seasons. The lowest values of amino acids contents in leaves, stem and pods were obtained in untreated Xera and Poulista plants in both seasons.

The differences between Xera and Poulista in their pod quality are a result of their genotype variation. In this respect, Abdel-Mawgoud et al. (2005) reported that snap bean cultivars differed in their pod quality.

The enhancing effect of antioxidants, i.e. ascorbic acid on pod quality maybe related to its major role in several metabolic processes such as photosynthesis and also, regulating coenzymatic reactions, therefore carbohydrates and proteins are metabolized (Barakat et al., 2015).

Similar results were documented by El-Bassiouny et al. (2005) they mentioned that faba bean plants foliar sprayed with ascorbic acid increased the total carbohydrate, and agreement whith those found by Sadak et al. (2010) and El-Sayed (2013) on faba bean.

From the obtained results in this study, it could be concluded that improving growth and pods yield and pod quality of Xera or Poulista cultivars growing under El-Fayoum governorate conditions can be occurs by treating snap bean plants with oxalic or ascorbic acid 3 times (20, 30, 40 days) from planting at the concentration of 500 ppm.

Table 6: Effect of cultivars and foliar spraying of different antioxidant substances on amino acid content (mg/g^{-1} D.W.) in leaves, stem and pods of snap bean plants during 2016 and 2017 seasons.

Treatments		Amino acid leaves		Amino acid stem		Amino acid pods	
cultivars	Treatment	2016	2017	2016	2017	2016	2017
Xera	Main	29.1	28.1	21.1	22.0	35.1	34.1
Poulista	effect	29.0	28.3	22.8	23.4	35.1	33.0
Main effect	Control	21.1	21.8	17.1	18.5	26.0	26.7
	Indole acetic	29.2	27.3	23.4	22.0	32.0	31.3
	Indole butyric	27.7	28.2	20.7	20.8	27.7	29.2
	Salicylic	29.0	28.3	21.5	23.8	34.0	33.7
	Ascorbic	31.2	29.3	21.8	24.0	41.0	37.7
	Oxalic	32.2	31.7	20.8	23.3	48.3	42.3
	Tartaric	30.2	29.5	22.7	23.3	34.0	34.7
	Citric	31.8	29.7	27.5	26.0	38.0	33.2
Xera	Control	19.2	19.7	15.1	16.7	26.0	25.3
	Indole acetic	28.3	26.3	22.7	21.7	32.0	31.3
	Indole butyric	26.0	27.3	20.0	20.7	27.7	28.3
	Salicylic	30.3	28.3	21.7	24.0	34.0	33.7
	Ascorbic	32.3	30.3	20.5	23.7	41.0	39.0
	Oxalic	32.0	31.3	18.7	21.3	48.3	43.7
	Tartaric	30.3	30.7	22.0	22.7	34.0	35.0
	Citric	34.0	31.0	28.0	25.7	38.0	36.7
Poulista	Control	23.0	24.0	19.0	20.3	26.0	28.0
	Indole acetic	30.0	28.3	24.2	22.3	32.0	31.3
	Indole butyric	29.3	29.0	21.3	21.0	27.7	30.0
	Salicylic	27.7	28.3	21.3	23.7	34.0	33.7
	Ascorbic	30.0	28.3	23.0	24.3	41.0	36.3
	Oxalic	32.3	32.0	23.0	25.3	48.3	41.0
	Tartaric	30.0	28.3	23.3	24.0	34.0	34.3
	Citric	29.7	28.3	27.0	26.3	38.0	29.7
LSD5%							
cultivars		n.s.	n.s.	0.6	0.3	n.s.	n.s.
Treatment		1.3	1.5	1.3	1.5	1.1	1.2
Interaction		1.9	2.1	1.8	2.1	1.6	1.7

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تأثير بعض مضادات الأكسدة على نمو والقدرة الإنتاجية لصنفين فاصوليا تحت ظروف محافظة الفيوم

الملخص العربى :

البوليستا والاكسيرا من أهم أصناف الفاصوليا المزروعة فى الفيوم سواء للسوق المحلى أو للتصدير. ومضادات الأكسدة عبارة عن مركبات عضوية مثل الأحماض العضوية والهرمونات .ركزت الدراسات الحديثة على الأدوار النافعة لهذة المواد فى تحسين أداء النباتات. ولذلك تم اجراء تجربتين حقليتين أثناء خريف عام ٢٠١٦ و ٢٠١٧ بالتوالى فى مزرعة خاصة بمحافظة الفيوم – مصر وذلك لدراسة تأثير ٧ مضادات أكسدة وهى (أحماض الأندول أسيتك والأندول بيوترك والأسكوربيك والسيترك والسالسليك والطرطيرك والأوكساليك) وكانت المعاملات رشا على المجموع الخضرى بتركيز ٥٠ ملى مول لكلا منهم) على صفات النمو ومحصول القرون الخضراء وجودة القرون لنباتات كلا من صنفى الاكسيرا والبوليستا. وقد زرعت البذور فى سبتمبر وكان تصميم التجربة هو قطع منشقة وتم رش مضادات الأكسدة بعد ٢٠ يوم من الزراعة ثم بعد ٣٠ و ٤٠ يوم. أخذت العينات النباتية بعد ٥٠ يوم و٧٠ يوم وذلك لأجل أخذ القياسات الخضرية وتقديرات المحصول وجودة القرون.

أظهرت النتائج تميز صنف الاكسيرا فى طول القرون ومحصول النبات من القرون الخضراء وتميز أيضا بارتفاع محتوى أوراقه من الكلورفيل ومحتوى قرونه من الأحامض الأمينية وعلى الجانب الآخر تميز صنف البوليستا فى طول نباتاته وارتفاع محتوى سيقانه وقرونه من الكربوهيدرات وارتفاع محتوى سيقانه من الأحامض الأمينية. كما أدت كل معاملات مضادات الأكسدة لزيادة فى كل صفات النمو الخضرى ومحصول القرون الخضراء وجودتها وأيضا محتوى الأوراق والسيقان والقرون الخضراء لنباتات الفاصوليا من الكاروتينات والكلوروفيل والكربوهيدرات والأحماض الأمينية مقارنة بالنباتات غير المعاملة بمضادات الأكسدة. كانت أقوى المعاملات تأثيرا فى تحسين الصفات المدروسة هى الرش بحمض الأوكساليك أو حمض الاسكوربيك مع تميز حمض الستريك فى زيادة محتوى السيقان من الأحامض الأمينية.

وفى ضوء النتائج السابقة يمكن استنتاج أن رش نباتات الفاصوليا صنفى الاكسيرا أو البوليستا بحمض الأوكساليك أو الأسكوربيك ثلاث مرات علي عمر(٢٠ ، ٣٠ ، ٤٠ يوما) من الزراعة بتركيز ٥٠ ملي مول ادى الى تحسن كبير فى صفات النمو ومحصول وجودة القرون الخضراء للفاصوليا تحت ظروف محافظة الفيوم.