Middle East Journal of Applied Sciences 3(2): 70-75, 2013
ISSN 2077-4613

Effect of foliar application of some antioxidants on growth, yield and chemical composition of Lettuce plants (*Lactuca Sativa* L.) under plastic house condition.

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ABSTRACT

Two field experiments were carried out during two successive winter seasons of 2012 and 2013 in the experimental station of National Research Centre at Nubaria, Behira Governorate, Egypt to assess the response of Romain lettuce cultivar plants (*Lactuca sativa* L.) cv. Nevada to some antioxidants treatments on morphological growth characters, yield and leaves chemical constituents. Aqueous solutions of the antioxidants as foliar spray ; i.e., Ascorbic acid (Vitamin C) at 25, 50 and 100ppm, Vitamin E at 0, 500 and 1000 ppm. Obtained results reflected that the highest values of growth parameters expressed as (plant heights, number of leaves, stem length and diameter as well as fresh and dry weight of all plants), total yield and heads quality i.e. (plant fresh weight and head diameter as well as the contents of leaves on nitrogen and protein) were obtained by ascorbic acid at 100 ppm with vitamin E at 1000 ppm. On the contrary, the lowest values of growth parameters, total yield and heads quality were obtained by foliar sprayed ascorbic acid at low level (25ppm) with untreated of vitamin E. On the other hand, the lowest value of NO_3 was obtained by foliar sprayed of high level of ascorbic acid at 100 ppm with low level of vitamin E (500ppm).

Key words: Lettuce- Ascorbic acid (Vitamin C) -Vitamin E (Alphatocopherol)- growth parameters- total yield - heads quality.

Introductio

Lettuce (*Lactuca sativa* L.) is the most popular among the salad crops. It is rich in vitamins and minerals (Choudhury, 1967). Also, lettuce was grown in Egypt for local consumption and export.

Ascorbic acid (Vitamin C) acts as coenzyme reaction by which carbohydrates, fats and protein and metabolized. Vitamin C led to increase nucleic acid content especially RNA Smirnoff and Wheeler (2000) reported that ascorbic acid is an abundant component of plans. It reaches a concentration of over 20 mM in chloroplasts and occurs in all cell compartments including cell wall. Vitamin C functions as antioxidant, an enzyme factor and as growth regulating factor. It plays an important role in different processes, including photosynthesis, photoprotection, cell wall growth and cell expansion resistance to environmental stresses of synthesis of ethylene, gibberellins, anthocyanins and hydroxyproline (Nicholas and Wheeler, 2000). The application of ascorbic acid can mitigate the harmful effects of salt stress and may have stimulatory effects on plants, for example, ascorbic acid is synthesized in the higher plants and affects plant growth and development. It is a product of D-glucose metabolism which affects some nutritional cycles activity in higher plants and play an important role in the electron transport system El-Kobisy *et al* (2005). Moreover, the application of ascorbic acid caused significantly increases on growth parameters and total yield of tomato plants AbdEl-Halim (1995). In the same respect, Talaat (2003) detected that foliar application of ascorbic acid increased the content of macronutrients N P K of sweet pepper fruits. Ascorbic acid increased carbohydrates and total nitrogen percent, Tarraf, *et al* (1999). However, Sally and Mervat (2012) found that, ascorbic acid caused superior effects on lettuce plant height, number of leaves, leaf area / plant, fresh and dry weights of leaves, as well as stem length and diameter. As well as increased total chlorophyll, total carbohydrates, total phenols, and N, P, K %. In the same time significantly increased average head fresh and dry weights and head diameter and yield quality by increasing TSS%. Other investigators found similar results on the stimulatory effects of ascorbic acid on other plants such as on pea Helal *et al* (2005), eggplant El-Tohamy *et al* (2008), sweet pepper Shehata *et al* (2002), Masahumi *et al* (2008), Khafagy *et al* (2009) and El-Hifny and El-Sayed (2011).

Vitamin E (Alpha-tocopherol) is an essential vitamin for humans and animals. However, it is exclusively synthesized in photosynthetic organisms DellaPenna (2005). It is lipid-soluble antioxidant and in green plant tissues it is localized in the chloroplast envelope and thylakoid membranes, but also in the plastoglobuli, small structures within the chloroplasts, attached to the thylakoid membranes and composed of lipids and proteins Vidi *et al* (2006) and Matringe *et al* (2008). Vitamin E it is also a powerful biological antioxidant Moreover, fertilizers and amendments also induced positive effects on ameliorate the bad effects of salt stress Hussein *et al* (2007). In the same respect, phytoregulator compounds (Vitamin E) suggested to elevate and tolerate the

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adverse effects of biotic and abiotic stresses such as moisture and salt stress on plant growth and yield (Demiral and Turkan 2005; RagaBabo *et al* 2005). However, El-Bassiony *et al* (2005) stated that the foliar spray with all treatment of antioxidants on bean plants induced increments on the number of branches, leaves and leaf area/ plant, fresh and dry weights of shoots. On the other hand, Hussein and El-Greadly (2007) found that all onion plant growth did not show any significant effect by spraying Vitamin E. Nevertheless, significant responses were detected on bulb diameter, fresh weight of bulb and dry matter of bulbs. However, Abd EI-Hakim (2006) and Al-Qubaie (2012) previous studies emphasized the beneficial effects of antioxidants on growth characters, leaf chemical composition, yield and yield components of different horticultural crops.

The aim of this study was to increase the quality and quantity of lettuce fresh head yield by using different levels of two vitamins.

Materials And Method

Field trails were carried out at the Experimental Station of National Research Centre at Nubaria region North Egypt during the winter seasons of 2012 and 2013 using (Romain lettuce cultivar), to study the efficiency of foliar application of some antioxidants (Vitamins C and E) to improve plant growth and increase Lettuce plants quantity and quality of yield. Lettuce seeds cv. Nevada were planted in the nursery 20 of November 2011 and 2012 seasons, respectively. The experiments included three levels of ascorbic acid (25, 50 and 100 ppm) and three levels of tochopherol (0, 500, and 1000 ppm). Transplanting was carried out on January 10^{th} and 12^{th} of 2011 and 2012, respectively at both sides of ridges. Spacing between plants within rows was 25 cm. The experimental design was split plot system in randomized complete blocks with three replications. The main plots were allocated for the levels of vitamin C (25, 50 and 100 ppm) and the sub-plots were occupied by the levels of vitamin E (0, 500 and 1000 ppm). Each sub-plot was 12 m^2 consisted of 4 rows each was 0.75m in width and 4 m in length. Nitrogen fertilizer in form of ammonium sulphate (20.6% N) was applied at rate of 100 kg / f in the two equal portions at 21 and 45 days after transplanting. Calcium super phosphate (15.5% P O) was also applied at rate of (200 kg / fed.) through soil preparation. Potassium sulphate (48% K_2O) was applied at rate of (50 kg / fed.) in two equal split applications, i.e., 4 and 8 weeks from transplanting. The recommended agricultural practices for commercial lettuce production in plastic house were followed. Harvesting was carried out at 90 days after transplanting.

Data Recorded:

Growth Characters:

A random sample of ten lettuce plants was taken from the two outer rows of each sub-plot, 12 weeks after transplanting to investigate the following growth parameters: shoot length (cm), leaf area (cm^2 /plant), leaves number/plant, fresh and dry weight of leaves (g) / plant, as well as diameter and length of the stem (cm).Total chlorophyll concentration was determined in fresh leaves according to the method of Witham *et al* (1971).

Yield and its Components:

At harvesting time, heads from the two inner rows of each sub-plot were used in estimating lettuce yield and some of its components as follow:

1- Average head fresh weight (g/plant).
2- Total head yield (kg/m^2)
3- Head diameter (cm).

Chemical Analysis:

Total nitrogen concentration in dry leaves was determined using the micro-kjeldahl method, as described by Ling (1963). Phosphorus, potassium and No_3 contents were determined in dried leaves following the method of Chapman and Pratt (1961). However, the protein percentage in lettuce leaves was accounted by multiplying nitrogen content by 6.25. All the recorded data were statistically analyzed according to Gomez and Gomez (1984).

Results And Discussion

Plant growth characters:

1-Effect of levels of vitamin C:

Data in Table (1) revealed that application of 50 or 100 ppm ascorbic acid as a foliar application had a favorable effect on all growth parameters of lettuce plants compared to low level 25 ppm. The highest plant heights, number of leaves, stem length and diameter as well as fresh and dry weight of all plant organs were recorded with plants treated with 100 ppm ascorbic acid compared with other treatments. The increments on fresh weight of leaves estimated by 6.07 % compared with low level (25ppm). Also, the increase in dry weight of leaves estimated by 12.78% compared with low level (25ppm). However, foliar sprayed by high level (100ppm) significantly increased leaf area plant, dry weight of leaves, stem length and diameter compared to all different levels. In this respect, Smirnoff and Wheeler (2000) reported that ascorbic acid has been implicated in regulation of cell division. These results are in accordance with those obtained by Gamal El-Din (2005) who reported that foliar application of ascorbic acid increased plant growth of sunflower plants. These treatments might be attributed to the postulation of Shaddad *et al*. (1990) who assumed that the effect of ascorbic acid on plant growth may be due to the substantial role of ascorbic acid in many metabolic and physiological processes. These results are in accordance by other plants such as on pea Helal *et al* (2005), eggplant El-Tohamy *et al* (2008), sweet pepper Shehata *et al* (2002), Masahumi *et al* (2008), Khafagy *et al* (2009) and El-Hifny and El-Sayed (2011).

2- Effect of levels of vitamin E:

Data presented in Table (1) elucidate that foliar spray of two levels of tocopherol (vitamin E) on growth parameters of lettuce plants, increased significantly all criteria of vegetative growth expressed plant height, number of leaves/plant, , leaf area, fresh weight of leaves, stem length and diameter as well as total chlorophyll contents compared to control. However, application of 1000 ppm (vitamin E) tocopherol separately increased fresh weight of leaves by 11.85 % than the corresponding values of the control plants. Vitamin E at 500 ppm or 1000 ppm application significantly increased all tested morphological parameters, the highest values were obtained at 1000 ppm application compared with those obtained by low level and untreated plants. Similar results were obtained by El-Basiouny (2005) who reported that foliar spray with tocopherol on bean plants induced increments in growth parameters and yield components. The essential role of antioxidants on promoting cell division and the biosynthesis of organic foods could result in enhancing growth aspects Noctar and Foyer (1998). The obtained results the effect of antioxidants materials (vitamin E) on growth and yield of lettuce plants were in agreement with that obtained by (Demiral and Turkan 2005; RagaBabo *et al* 2005, Vidi *et al* 2006, Matringe *et al* 2008 and Al-Qubaie 2012).

3- Effect of the interaction of vitamin C and vitamin E:

Data in Table (1) emphasized that the interaction effects were not significantly affected by all growth parameters i.e. plant height, number of leaves, leaf area /plant, fresh and dry weight of leaves, stem length and diameter as well as total chlorophyll content. The highest values of growth parameters were obtained by ascorbic acid at 100 ppm with vitamin E at 1000 ppm. On the contrary, the lowest values of growth parameters were obtained by foliar sprayed ascorbic acid at low level (25ppm) with no treated of vitamin E.

Total yield and heads quality:

1-Effect of levels of vitamin C:

As regarding on Table (2) that foliar application of high level of ascorbic acid (100ppm) produced highly significant increases of total yield (kg/m^2) of lettuce and its different organs expressed as (plant fresh weight and head diameter) compared to other levels (50 or 25ppm). The increase in total yield (kg/m^2) was 5.19 % when compared by its low level (25ppm). These increases might be attributed to ascorbic acid can play an important role in the regulation of cell division, differentiation and enhancement of leaf expansion Noctar and Foyer, (1998) and Soha *et al*. (2010). These results are in agreement with those reported by Smirnoff and Wheelas (2000) on the function and metabolism of ascorbic acid. Blokhina *et al* (2003) stated that ascorbic acid has a wide range of important functions as antioxidant defense, photo protection and regulation of photosynthesis. In the same respect, the medium and high levels of ascorbic acid (50 or 100ppm) increased the contents of the percentage of nitrogen and total protein in lettuce leaves tissues But insignificant Table (3). The highest value of the percentage of NO_3 was obtained by foliar spraying of medium level of ascorbic acid (50ppm). The increment in NO_3 content could be explained by Talaat (2003) who found that the accumulation of NO_3 by ascorbic acid foliar application may be due to the positive effect of ascorbic acid on root growth.

2- Effect of levels of vitamin E:

Data in Table (2) reported that all the concentration of vitamin E (500 or 1000ppm) significantly increased total yield of lettuce plants (kg/m^2) and its different organs compared with untreated plants. However, the fresh weight of heads, head diameter and total yield (kg/m^2) increased by 32.45, 23.46 and 22.15% respectively by foliar spraying of vitamin E at high level (1000ppm) than the corresponding values of the control plants (no treated). In addition, vitamin E are a group of compounds synthesized only by photosynthetic organisms, in plants treated with vitamin E are believed to protect chloroplast membranes from photo oxidation and help to provide on optimal environment for total yield and its different organs could be explained by El-Tohamy and El-Greadly, (2007) they found that foliar application of vitamin E at 0.1 ml/l and 0.3 ml/l significantly improved vegetative growth and yield of bean plants compared to control plants especially at the higher concentrations. In addition, foliar spraying of low and high levels of vitamin E (500 and 1000ppm) significantly increased the percentage of nitrogen and protein contents in lettuce leaves tissue compared to the control treatments.

3- Effect of the interaction of vitamin C and vitamin E:

The interaction between source and levels of antioxidants materials Table (2) had no significant effect on total yield and heads quality of lettuce plants. The highest values of total yield and heads quality were obtained by ascorbic acid at 100 ppm with vitamin E at 1000 ppm. On the other hand, foliar spraying of high level of tow vitamins C and E at 100ppm of V.C and 1000ppm of V.E significantly increased the percentage of NO_3 content of leaves tissue. From the abovementioned results, it could be concluded that foliar application of the antioxidant treatments might be play an important role in many metabolic and physiological processes, through affecting the metabolism of photosynthesis process which led to increase in total soluble sugar content which influences and promoted all vegetative growth and total yield as indication for foliage quality.

Table 1: Effect of some antioxidant materials on growth characters of lettuce grown under plastic house (combined data of two seasons).

Concentrations ppm		Plant height (cm)	No. of leaves/ plant	Leaf area/plant (cm^2)	Weight of leaves (g)		Stem (cm)		Total chlorophyll (mg/g Dr.w)
Vitamin C	Vitamin E				fresh	dry	length	Wide	
25	0	27.84	69.51	3524.10	395.87	30.66	8.52	3.18	6.10
	500	31.09	70.70	3822.80	407.97	32.62	9.13	3.53	6.51
	1000	32.12	72.91	4052.51	432.89	35.38	9.88	3.85	7.08
Mean		30.35	71.04	3799.80	412.24	32.88	9.17	3.52	6.56
50	0	34.59	73.62	3657.54	406.07	31.63	9.24	3.43	6.30
	500	34.40	74.92	4031.05	420.77	33.97	10.29	3.84	6.97
	1000	37.03	77.15	4399.79	453.16	36.58	10.63	4.15	6.15
Mean		*35.34	*75.23	*4029.46	*426.66	*34.06	*10.05	*3.81	6.47
100	0	33.57	72.25	4036.29	400.75	32.29	9.86	3.72	6.21
	500	37.01	76.64	4169.63	451.77	36.50	10.88	3.86	7.01
	1000	41.56	77.97	4220.33	459.21	37.64	11.33	4.34	7.74
Mean		*37.38	*75.62	**4142.08	*437.24	**35.48	**10.69	**3.97	6.99
Average V. E	0	32.00	71.79	3739.31	400.90	31.53	9.21	3.44	6.20
	500	*34.16	*74.09	*4007.82	*426.84	*34.36	*10.10	*3.75	*6.83
	1000	**36.90	**76.01	**4224.21	**448.42	**36.53	**10.61	**4.11	*6.99
LSD at 5% level	V. C	2.29	0.58	70.34	12.24	0.42	0.05	0.14	NS
	V.E	1.28	1.06	100.96	10.26	0.45	0.21	0.14	0.46
	Inter.	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Effect of some antioxidant materials on total yield and head quality of lettuce grown under plastic house (combined data of two seasons).

Concentrations ppm		Plantfresh weight (g)	Head diameter (cm)	Total yield (kg/m^2)	%				
Vitamin C	Vitamin E				N	protein	P	K	No_3
25	0	451.57	41.72	5.65	2.03	12.67	0.39	5.36	0.61
	500	489.63	45.89	6.44	2.15	13.46	0.38	7.56	0.71
	1000	611.08	51.29	7.00	2.45	15.31	0.41	8.56	0.83
Mean		517.43	46.30	6.36	2.21	13.81	0.40	7.16	0.71
50	0	447.86	41.24	5.89	2.68	16.75	0.37	6.65	0.96
	500	509.05	44.86	6.57	2.78	17.40	0.37	7.84	1.14
	1000	618.98	53.12	7.01	2.56	16.02	0.40	8.74	0.57
Mean		525.30	46.41	6.49	2.68	16.72	0.41	7.75	0.89*
100	0	508.17	48.11	6.07	2.53	15.83	0.38	8.81	0.39
	500	558.04	55.48	6.50	2.89	18.08	0.40	8.67	0.22
	1000	634.32	57.41	7.50	2.79	17.42	0.41	9.11	1.53**
Mean		*566.84	*53.67	*6.69	2.74	17.11	0.40	8.86	0.71
Average V. E	0	469.20	43.69	5.87	2.41	15.09	0.38	6.94	0.65
	500	*518.91	*48.75	*6.50	2.61*	16.31*	0.39	8.02	0.69
	1000	**621.46	**53.94	**7.17	2.60*	16.25*	0.41	8.80	0.98
LSD at 5% level	V. C	17.28	1.87	0.16	NS	NS	NS	NS	0.12
	V.E	19.54	1.18	0.16	0.14	0.89	NS	NS	NS
	Inter.	NS	NS	NS	NS	NS	NS	NS	0.20

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