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RESPONSE OF SUMMER CABBAGE TO SOME ANTIOXIDANTS

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ABSTRACT

Two field experiments were conducted at the Agricultural Research Farm, Faculty of Agric., Minufiya University during seasons of 2004 and 2005 to investigate the effect of some antioxidants i.e., ascorbic acid (vit. C), thiamine (vit. B_1), citric acid (CA) and salicylic acid (SA) on vegetative growth, chemical composition, head physical characters and yield and its quality of cabbage grown in summer season. Results indicate that, all the used antioxidants treatments significantly increased plant height, stem diameter, fresh weight of stem, leaves / plant and whole plant, dry matter, total carbohydrates as well as the concentration of N, P and K of cabbage leaves. Moreover, in the presence of this antioxidants, head length, head diameter, number and weight of un-wrapped leaves/plant, edible head weight and total yield were significantly increased. On the other hand, NO_3-N accumulation decreased. In general, spraying plants with ascorbic acid, thiamine at the rate of 1000 mg / l and salicylic acid at the rate 300 mg / l gave the best values of vegetative growth and head characteristics.

Keywords: Cabbage, antioxidants, yield, chemical composition, nitrate concentration.

INTRODUCTION

Cabbage (*Brassica oleraceae* L.var.capitata) is a popular winter vegetable crop in Egypt and is grown in summer season during the last decades. Environmental conditions particularly high temperatures may limit the field production of cabbage during summer season and can reduce yield in principal production areas. Masle *et al.* (1993) reported that, when plants were exposed to high temperature, photosynthesis is limited by RUBP-Case Capacity. Chauhan and Senboku (1996) observed that hardening at 30 – 35°C decreased photosynthetic rates in YR Kinshun cabbage cultivar. High light and heat lead to elevate levels of toxic oxygen species photoinhibition and finally photooxidation, antioxidants, were found to exert positive effect and overcome the harmful effect of some environmental stress on plant growth (Cakmak and Marschner, 1992). Antioxidants, protect chloroplast and electron transport system. they also, stimulate respiration activities, cell division and many enzymes activities (Oertli, 1987). He also mentioned that, spraying plants with vit. C at 100 mg/l stimulated plant height and branching of chick pea. Bardisi (2004) concluded that ascorbic acid at 100 or 200 ppm obtained the maximum values of number of leaves/plant, diameter of both neck and bulb, total dry weight/plant and N, P and K uptake by leaves and bulb of garlic.

Vitamin-B_1 participates in plant growth and development indirectly of various growth factors such as cytokinins and gibberellins (Kodendaramaiah and Rao, 1985). Mostafa (2004) reported that, the best results with regard to

yield and fruit quality of Grand Nain Banana were achieved by spraying plants three times with vitamin B_1 at 2000 ppm.

Some studies have been also reported that citric acid had positive effects on plant growth and development. Abdel-Aziz, and Anton (2005) reported that foliar spray of soybean plants with 1000 ppm citric acid significantly increased growth and yield.

Salicylic acid was found to have an antioxidant effect and could overcome the deleterious effect of different stresses on plant by acting as chelating agent protect the reproductive organs from stress (Oota, 1972). Salicylic acid treatment resulted in an increase in number of flowers, pods/plant and seed yield of soybean (Zhao *et al.*, 1995). Bardisi (2004) reported that spraying garlic plants with salicylic acid at 50 ppm recorded maximum values of plant height, number of leaves/plant, diameter of both neck and bulb, total dry weight/plant and N, P and K uptake by leaves and bulb and N, P and K total uptake by plant.

Growing cabbage plants in warm conditions like summer season in Egypt, Table (1) has a harmful effect on growth and consequently on cabbage yield and quality. Therefore, the present work aimed to study the possibility of using ascorbic acid, thiamine, citric acid and salicylic acid to improve vegetative growth, yield and quality of cabbage during summer season.

MATERIALS AND METHODS

Two field experiments were carried out at the Experimental Farm of the Faculty of Agriculture, Minufiya University during two successive summer seasons of 2004 and 2005 to study the effect of ascorbic acid (vit. C), thiamine (vit. B_1), citric acid (CA) and salicylic acid (SA) as foliar application on growth, some chemical composition, yield and its quality of summer cabbage.

The monthly average maximum and minimum temperature during the growth period of cabbage plants are show in Table (1).

Table (1). The monthly average maximum and minimum temperature during the growth period of cabbage plants.

Months	2004		2005	
	Max.	Min.	Max.	Min.
April	26.4	11.6	27.2	13.1
May	31.5	16.9	32.0	16.5
June	33.1	19.5	33.2	19.9
July	33.4	20.8	34.5	21.5
August	33.5	20.7	34.0	21.5

Seeds of C.V. Balady Mohassan were sown on February 15th in both seasons and transplanted on April 15th and 10th during the two growing seasons 2004 and 2005.

A complete randomized block design with four replicates was adopted. The plot area was 16 m^2. each plot consisted of 5 ridges(4 m length and 80 cm wide). The transplants were spaced at 50 cm apart on one side of the ridge. A guard ridge was left between the treatments. All experimental

units received 250 kg ammonium sulfate (20.5% N), 100 kg potassium sulfate (48.0% K_2O) per feddan were equally divided and side dressed at 30, 60 and 90 days from transplanting and 200 kg/fed. calcium super phosphate (15.5% P_2O_5) was added during soil preparation. Other agricultural practices were applied as recommended.

This experiment included nine treatments as follows:

1. Control (cabbage sprayed with water).
2. Vitamin C at the rate of 500 mg/l.
3. Vitamin C at the rate of 1000 mg/l.
4. Vitamin B_1 at the rate of 500 mg/l.
5. Vitamin B_1 at the rate of 1000 mg/l.
6. Citric acid at the rate of 500 mg/l.
7. Citric acid at the rate of 1000 mg/l.
8. Salicylic acid at the rate of 200 mg/l.
9. Salicylic acid at the rate of 300 mg/l.

Each treatment was sprayed three times at 30, 60 as well as 90 days after transplanting. Plant sample was taken at randomly at 120 days after transplanting (five plants) from each experimental plots. The data were recorded.

1. Vegetative growth, i.e., plant height (cm), stem diameter (cm), fresh weight of stem, leaves/plant and whole plant weight as well as the percentage of dry matter in leaves, one hundred grams of fresh leaves (Edible head) from each treatment was weighted, cut into slices then dried in an oven at 70°C until constant weight and the dried slices of leaves were weighed then the dry matter was calculated.
2. **Chemical composition of plant leaves:**
   A. Total carbohydrates of dry leaves were determined colorimetrically using the phenol acid method according to Dubois *et al.* (1956).
   B. NO_3-N content was described by the methods of Singh (1988).
   C. Minerals concentrations: Total nitrogen was estimated in dry leaves using microkjeldahl method according to Ling (1963), phosphorus as the method of Snell and Snell (1954), potassium estimated using the Flame photometer according to Allen (1974) then their concentrations (%) were calculated.
3. Head physical characters, i.e., head length and diameter, number and weight of un-wrapped leaves / plant (kg), Edible head weight (kg) and total yield (ton / fed.).were recorded

All obtained data were subjected to statistical analysis with the help of CO-STAT program, and the L.S.D. at 5% level was calculated according to Gomez and Gomez (1983).

RESULTS AND DISCUSSION

1. Vegetative growth characteristics:

Data presented in Table (2) show the effect of foliar application of ascorbic acid, thiamine, citric acid and salicylic acid on plant height, stem diameter, fresh weight of stem, leaves and total plant as well as dry matter of leaves. Plants treated with vit. C, vit. B_1, citric acid and salicylic acid at different concentrations significantly increased the growth parameters as

compared to the control. Salicylic acid at 300 mg/l followed by vit. C and vit. B_1 at the rate 1000 mg/l recorded the highest values for all studied plant growth characters as compared with other treatments in both seasons. The positive effect of the antioxidants on growth might be attributed to their effect on counteracting drought, heat and diseases stresses as well as enhancing growth characters (Raskin, 1992 a). These results are in agreement with those obtained by Arisha (2000) on potato who found that foliar spray with vitamin C at different concentrations increased plant growth. The effect of Ascorbic acid certainly reflected on enhancing cell division and nutritional status resulting increasing the leaf area (Mostafa, 2004). Also, Kodendaramaiah and Rao (1985) suggested that Vitamin B_1 participates in plant growth and development indirectly by enhancing the endogenous hormones such as cytokinins and gibberellin. The results of Citric acid are in agreement with Abdel-Aziz, and Anton (2005) who reported that foliar spray of soybean plants with 1000 ppm of citric acid increased significantly growth and yield. Miernyk and Trelease (1981) found that citric acid is one of the organic acids presented in tricarboxylic acid cycle and synthesized either from acetyle-Co A, glycine and α-ketoglutaric, or malic acid conversion to citric acid. Concerning salicylic acid the obtainad results are in agreement with those obtained by Zhao *et al.* (1995), who found that application of SA increased growth rate and photosynthetic rate in soybean. These results are in harmony with those obtained by Bardisi (2004) using salicylic acid on garlic plant.

2. Chemical composition of plant leaves:

A. Total carbohydrates concentration:

Presented data in Table (3) indicated that, foliar spray of cabbage plants with vit. C, vit. B_1 and citric acid at different rates and salicylic acid at the rate of 300 mg/l increased the concentration of total carbohydrates in leaves as compared with the control. In general, SA at the rate of 300 mg/l, vit B_1 at the rate of 1000 mg/l and citric acid at the rate of 500 recorded maximum values of total carbohydrates. These mean values recorded 33.6, 30.6 and 29.2% in the first season, respectively. These results are in harmony with those reported by Kodendaramaiah and Rao (1985), Taiz and Zieger (1998), Raskin (1992 a) and Zhao *et al.* (1995). The positive effects of ascorbic acid might be due to its involvement in the main metabolic process especially with energy Co-enzymes, carbohydrate metabolism and improved biosynthesise activity (El-Khayat, 2001).

B. Nitrate concentration:

Data presented in Table (3) indicated that, vit. C, vit. B_1, citric and salicylic acid significantly decreased nitrate concentration. Best results in this concern, were obtained from citric acid at the rate of 500 mg/l followed by vit. C at the rate of 1000 mg/l then vit. B_1 at the rate of 500 mg/l. It was suggested that Vitamin B_1 participates in plant growth and development indirectly by enhancing the endogenous hormones such as cytokinins and gibberellins (Kodendaramaiah and Rao (1985). Ascorbic acid (vitamin C) foliar application was reported to induce many stimulating effects of some physiological activities of different plants.

Table (2): Effect of some antioxidants on the vegetative growth characteristics of cabbage plant during 2004 and 2005 seasons.

Characters / Treatments	2004 season						2005 season					
	Plant height (cm)	Stem diameter (cm)	Fresh weight (kg)			Dry matter (%)	Plant height (cm)	Stem diameter (cm)	Fresh weight (kg)			Dry matter (%)
			Stem	Leaves	Whole plant				Stem	Leaves	Whole plant	
Control	50.00	3.60	0.630	2.747	3.377	5.319	45.70	3.17	0.670	3.797	4.467	5.62
Vit. C[1] 500 mg/l	59.00	4.21	0.700	4.147	4.847	6.439	51.80	3.98	0.700	4.227	4.927	6.91
Vit. C 1000 mg/l	66.30	4.63	0.620	5.120	5.740	7.901	57.30	4.96	0.643	5.190	5.833	8.06
Vit. B_1[2] 500 mg/l	58.30	4.60	0.670	3.933	4.603	7.612	49.70	4.12	0.783	4.824	5.607	6.35
Vit. B_1 1000 mg/l	64.00	4.73	0.800	4.790	5.590	7.727	56.80	4.83	0.790	4.977	5.767	7.59
CA[3] 500 mg / l	63.30	4.21	0.770	3.743	4.513	6.398	50.40	4.37	0.655	4.932	5.587	7.49
CA 1000 mg / l	55.90	4.37	0.660	4.050	4.710	7.121	53.20	4.43	0.647	4.817	5.464	7.59
SA[4] 200 mg / l	60.33	4.63	0.700	3.833	4.533	7.882	54.20	4.32	0.800	4.720	5.520	6.17
SA 300 mg / l	68.00	4.93	0.830	4.940	5.770	8.440	59.90	5.03	0.930	4.970	5.900	8.50
L.S.D 5%	7.40	0.55	0.11	0.42	0.05	1.10	4.00	0.72	0.07	0.34	0.11	1.17

1; Ascorbic acid (Vit. C). 2; thiamine (vit. B_1). 3; citric acid (CA). 4; salicylic acid (SA)

Table (3). Effect of some antioxidants on some chemical components of cabbage leaves during 2004 and 2005 seasons.

Characters / Treatments	2004 season					2005 season				
	Total carb. (mg/g. d.wt.)	No_3 accumulation (mg/kg dry wt.)	N %	P %	K %	Total carb. (mg/g. d.wt.)	No_3 accumulation (mg/kg dry wt.)	N %	P %	K %
Control	220.48	92.93	3.26	0.324	3.45	232.04	78.68	3.46	0.424	3.34
Vit. C 500 mg/l	228.54	85.40	3.96	0.438	3.65	252.62	69.51	4.10	0.448	4.26
Vit. C 1000 mg/l	240.63	59.81	4.00	0.400	3.81	247.22	32.60	4.18	0.469	4.42
Vit. B_1 500 mg/l	232.28	60.94	3.55	0.436	4.06	262.20	37.34	3.69	0.440	4.80
Vit. B_1 1000 mg/l	288.04	80.34	3.63	0.469	4.01	327.70	70.10	3.75	0.579	4.59
CA 500 mg / l	284.82	47.49	3.35	0.471	4.19	306.30	30.50	3.56	0.519	4.63
CA 1000 mg / l	249.88	65.31	3.40	0.484	3.87	276.98	45.40	3.57	0.613	4.32
SA 200 mg / l	195.21	80.38	3.77	0.460	3.58	214.32	72.21	3.37	0.484	3.93
SA 300 mg / l	294.53	65.11	4.24	0.538	3.52	357.40	44.20	4.79	0.623	4.08
L.S.D 5%	30.94	4.56	0.36	0.10	0.34	23.45	8.24	0.30	0.13	0.42

In addition, Salicylic acid has been found to increase catalase activity which indicate an activation of the cellular antioxidant system and enzyme level (Knorzer *et al.*, 1999).

C. Minerals concentrations:

Data in Table (3) indicated that, nitrogen percentage in leaves showed higher levels with spraying by Salicylic acid at 300 mg/l (30.1% in the first season and 38.4% in the second one) followed by spraying Ascorbic acid at 1000 mg/l, (22.7 and 20.8% in the first and second seasons, respectively. Then spraying vit. C at 500 mg/l (21.5% in the first season and 18.5% in the second one). The lowest nitrogen percentage was recorded by control plants in both seasons.

Phosphorus percentage revealed significant differences between treatments in the both seasons. The best results in this concern were obtained from salicylic acid at rate 300 mg/l followed by citric acid at rate of 1000 mg/l then vitamin B_1 at rate of 1000 mg/l.

Potassium percentage in leaves was increased by the foliar application with antioxidants. The highest potassium percentage was recorded by citric acid at 500 mg/l, vitamin B_1 at 500 mg/l and vitamin B_1 at 1000 mg/l in the first season. While the second season, the highest potassium percentage in leaves was recorded by spraying vitamin B_1 at 500 mg/l followed by citric acid at 500 mg/l then vit. B_1 at 1000 mg/l .

The beneficial influence of these antioxidants on increasing the tolerance to various stresses as well as improving the growth traits surely reflected on stimulating the nutritional status of the plants. These advantages of the antioxidants may be attributed to enhancing the uptake of the nutrients by the plants (Raskin, 1992 a and Ahmed *et al.*, 2002).

The present data are in harmony with those obtained by Bardisi (2004) using salicylic acid and ascorbic acid on garlic. Mostafa (2004) using ascorbic acid and vitamin B_1 on banana plants.

3. Head physical characteristics and total yield:

Data presented in Table (4) illustrate that head physical characteristics expressed as head length, head diameter and un-wrapped leaves, number and weight per plant, edible head weight and total yield ton per feddan were significantly increased by using antioxidants such as vit. C, vit. B_1, citric and/or salicylic acid as compared with the control. In general, vit. C at the rate of 1000 mg/l, followed by salicylic acid at the rate of 300 mg/l then vit. B_1 at the rate of 1000 mg/l recorded the highest values in all measured characters in both seasons. The increments in marketable yield (ton/fed) were about 70.9% and 32.1% for SA at 300 mg/l, 69.9% and 30.6% for ascorbic acid at 1000 mg/l and 65.5% and 29.1% for vitamin B_1 at 1000 mg/l above the control in the first and second seasons, respectively.

The results of vitamin C were agreed with those reported by Oertli (1987) on cowpea, and Arisha (2000) on potato. They concluded that spraying cowpea and potato with vitamin C at 50 ppm and 200 ppm, respectively increased grains yield of cowpea and total yield/fed of potato.

Table (4). Effect of some antioxidants on head physical characteristics and total yield of cabbage plant during 2004 and 2005 seasons.

Characters / Treatments	2004 season						2005 season					
	Head (cm)		Un-wrapped leaves / plant		Edible head weight (kg/ p)	Marketable yield (ton / fed)	Head (cm)		Un-wrapped leaves / plant		Edible head weight (kg/ p)	Marketable yield (ton/ fed)
	Length	Diameter	Number	Weight (kg/ p)			Length	Diameter	Number	Weight (kg/ p)		
Control	21.33	24.33	10.00	0.790	1.957	27.016	22.67	23.33	9.30	0.843	2.954	35.736
Vit. C 500 mg/l	30.33	33.33	11.00	1.300	2.847	38.776	29.33	31.33	11.00	1.187	3.040	39.416
Vit. C 1000 mg/l	37.00	41.67	14.30	1.210	3.907	45.920	35.90	41.67	13.70	1.033	4.157	46.664
Vit. B_1 500 mg/l	28.33	31.33	14.00	1.230	2.703	36.824	28.33	27.67	10.00	1.277	3.547	44.856
Vit. B_1 1000 mg/l	32.33	35.30	13.30	1.440	3.350	44.720	30.90	28.67	11.00	1.420	3.557	46.136
CA 500 mg / l	27.67	30.33	11.00	1.320	2.423	36.104	28.00	25.00	12.30	1.240	3.692	44.696
CA 1000 mg / l	28.33	30.33	11.30	1.130	2.920	37.680	30.37	28.33	14.00	1.185	3.632	43.712
SA 200 mg / l	28.33	30.00	12.30	1.120	2.713	36.264	28.99	30.67	10.70	1.197	3.523	44.160
SA 300 mg / l	35.67	38.00	14.30	1.113	3.827	46.160	33.42	35.44	12.70	0.957	4.013	47.200
L.S.D 5%	5.32	4.34	1.33	0.12	0.41	2.11	6.09	3.90	n.s	0.13	0.37	2.45

Salicylic acid at 200 mg/l. gave the maximum number and yield of micro tubers/plantlets of potato (Nawar, 2001). The effect of thiamine may be due to the role of thiamine which is combined with 2 molecules of phosphoric acid to form Thiamine pyrophosphate (TPP) which is the most active form that acts as a coenzyme necessary for oxidative decarboxylation of pyruvic acid from glycolysis to active acetale in kreb's cycle and this, in turn, affect the growth and yield plants (El-Ghamriny *et al.,* 1999).

Salicylic acid application increased phenolic compounds. However, these compounds also include lignin, which found in cell walls of various types of supporting and conducting tissue. It is deposited in the thickened secondary walls and can also occur in the primary wall. Thus, these compounds are necessary for developing seeds and their roles in plant mechanism of defense (Taiz and Zeiger, 1998). The increases of total yield/fed might be due to the increase of dry matter and N, P, K uptake (Tables 2 and 3).

Generally, it can be concluded that in addition to the beneficial effects of antioxidants on improving cabbage growth in summer season and pronounced increase in cabbage productivity. The plant spraying with vit. C and vit. B_1 at the rate of 1000 mg/l and salicylic acid at the rate of 300 mg/l gave the best results.

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استجابة الكرنب الصيفى لبعض مضادات الأكسدة

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أجريت تجربتان حقليتان بمزرعة كلية الزراعة بشبين الكوم جامعة المنوفية بهدف دراسة تأثير بعض مضادات الأكسدة (فيتامين ج ، فيتامين ب١ وحمض الستريك وحمض السلسيليك) على النمو الخضرى وصفات الرأس والمحصول والجودة والتركيب الكيماوى للكرنب المنزرع فى فصل الصيف .

ويُمكن تلخيص أهم النتائج فى الآتى :

- أدى رش النباتات بفيتامين ج وفيتامين ب١ وحمض الستريك وحمض السلسيليك بجميع التركيزات المستعملة إلى زيادة طول النبات وقطر الساق والوزن الأخضر للساق والأوراق والنبات ككل ، بالإضافة إلى زيادة النسبة المئوية للمادة الجافة للأوراق ، وكذلك التركيب الكيماوى أو القيمة الغذائية لرأس الكرنب (الكربوهيدرات الكلية والنسبة المئوية للنيتروجين والفوسفور والبوتاسيوم) كما أدى الرش بهذه المضادات إلى تقليل النترات فى الأوراق .
- كذلك أدت مضادات الأكسدة المستعملة إلى زيادة طول وقطر الرأس ، ووزن الأوراق الغير ملفوفة لكل نبات ، ووزن الرأس . الجزء الاقتصادى ، المحصول الكلى للفدان .
- وبصفةٍ عامةٍ أدى الرش بفيتامين ج وفيتامين ب١ بتركيز ١٠٠٠ ملليجرام / لتر وحمض السلسيليك بتركيز ٣٠٠ ملليجرام / لتر إلى الحصول على أفضل النتائج لصفات النمو الخضرى وجودة المحصول .