Using Some Antioxidant Substances for Enhancing Thermotolerance and Improving Productivity of Pea (*Pisum sativum L*) Plants Under Local Environment of Early Summer Season.

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Abstract: Increasing evidence suggests that exogenous antioxidants may lead to the enhancement of thermotolerance and improvement of growth and productivity in plants. This study was designed in private farm at Kafr Hassan, Samannoud district, Garbia governorate (10 Km apart of Mansoura city), to investigate the influence of some antioxidant substances, i.e., vitamins C (250 ppm) and E (150 ppm), calcium (2000 ppm), zinc (100 ppm), selenium (50 ppm) and salicylic acid (150 ppm), as well as yeast extract (25ml/l) towards better thermal tolerances and higher productivity of pea plants cv. Master-B under local environmental condition of two early summer seasons of 2005 and 2006. The results showed that exogenous foliar applications with mentioned substances were most effective in enhancing heat tolerance in pea plants, which were manifested by improving vegetative growth parameters (plant height, number of branches and leaves/plant, fresh and dry weight/plant as well as leaf area/plant), yield and yield attributes (pod length, number of seed/pod and weight of 100-green seeds) and seed quality (vitamin C and reducing and non-reducing sugars), as well as, leaf chlorophyll contents, compared with untreated control (tap water) in the two growing seasons. However, the favorite application in diminished order were Ca and Zn combination, Zn, Ca, SA, V.C., Se and V.E. combination, yeast extract, Se and at least V. E. This enhancement of yield capacity was related to pod quality, number of seed/pod and weight of 100-green seeds. In contrast, plants exposure to heat stress without treatment (control), during seed filling, decreased pod length, number of seed/pod and seed weight, and consequently, reduction of fresh and dry yields. From the obtained results it could be concluded that spraying pea plants, growing under milder thermo-stress of local early summer season, with some antioxidant substances can enhance growth and yield capacities.

Keywords: *Pisum sativum L,* Antioxidants, thermotolerance.

INTRODUCTION

Peas are commonly grown in the temperate and to a lesser extent in the subtropical regions of the world. Average growing season temperatures of 13-18°C produce optimum yields (Muehlpauer and McPhee, 1997). Temperature levels beyond an organism's optimal life range are regarded as a major abiotic stress (Hong-Tao *et al.*, 2006).

Growing peas during the early summer season under local environmental conditions (milder thermo-stress, Table 1) resulted in anticipated the normal termination of photomeres production by the apical meristem, while sever stress caused a rapid interruption of reproductive organs development (Guilioni, 1998).

Higher temperature stress either accelerates the formation of toxic reactive oxygen species (ROS), *i.e.*, H_2O_2, OH, O^-_2 levels within plant tissues or impairs the normal defense mechanisms against ROS toxic effects. Such stress induce higher O^-_2 photo-reduction through chloroplast, or electron transport disturbance, and donation of electron to O^-_2 within mitochondrial, and finally led to generation of toxic ROS (Bowler *et al.*, 1992 and Elstner and Osswald 1994). Also, heat stress results in increased membrane fluidization (Sangwan *et al.*, 2002). Moreover, ROS damaged chloroplast, reduced carbohydrate synthesis and exportation and hasted oxygen senescence, attack cell membranes, led to their degradation and leakage of cell solutes, denaturation of proteins and enzymes, damage of nucleic acids, degradation of chlorophyll and suppression of all metabolic processes, and finally senescence and death of cells and tissues (Dicknson *et al.*, 1991).

The imposition of biotic and abiotic stress conditions can give rise to excess concentration of active oxygen species (AOS) resulting in an oxidative damage at the cellular level. Therefore, antioxidants and antioxidant enzymes function to interrupt the cascades of uncontrolled oxidation in each organelle. (Shigeoka *et al.*, 2002).

At such environment, antioxidants, *i.e.*, vitamins C and E, calcium, zinc and selenium as well as, yeast extract and salicylic acid, etc., due to their molecules auto (ox-reduction) properties, act as cofactors for some specific enzymes, *i.e.*, dismutases, catalases and peroxidases, those catalyzed breakdown of the toxic H_2O_2, OH, O_2 (radicals) (Romheld and Marschner, 1991; Bowler *et al.*, 1992 and Aono *et al.*, 1993). Antioxidants also should be beneficial in the protection of the structure and function of photosystems against excess light (Rajagopal *et al.*, 2005).

Recently, many substances include antioxidants were exogenously applied to protect plant against adverse effects of environmental/oxidative stress. In this respect, Gong *et al.*, 1998 suggested that calcium may have a role in heat stress signaling. It has attracted much interest in plant physiology and molecular biology because of its function as a second messenger in the signal conduction between environmental factors (such as high temperature) and plant responses in terms of growth and development. This function of calcium is causally related to its strict compartmentation at cellular level (Marschner., 1995 and Sanders *et al.*, 2002).

It was stated that zinc plays a defensive protective role against adverse effects of higher temperature via its antioxidants and gene regulatory functions (Cakmak and Marschner, 1988 and Chesters, 1992). Moreover, it was reported that calcium (Ferguson, 1988) and zinc Cakmac and Marschner, 1988) enhance translocation of bioassimilates and nutrients within tissues as they activate the membrane transporter enzymes.

Selenium plays an important regulatory role in improving the tolerance of plant to high temperature stress through increasing chlorophyll content and activating antioxidant enzymes (Shang QingMao *et al.*, 2005). Also, through its antioxidative function, Se may delay plant senescence and to promote plant growth (Hartikainen., 2002).

Concerning, utilization of vitamins as antioxidants, many investigations had been carried out to protect plants against adverse effects of environmental stresses.

In this regard, vitamin C (L- ascorbic acid) is a multifunctional compound in both plants and animals (Gabriela *et al.*, 2003). It plays an important role in photosynthesis as an enzymes co-factor including synthesis of abscisic acid, ethylene, gibberellins and anthocyanin and control of cell growth (Smirnoff and Wheeler, 2000). Also, it's a good scavenger of activated oxygen as O_2^-, OH^-, $^1O_2$ and reducing hydrogen peroxide (H_2O_2) to water via ascorbate peroxidase reaction (Bodannes and Chan, 1979 and Noctor and Foyer, 1998), as well as, enhancing the accumulation of chlorophyll and delay senescence (Mattagajasingh and Kar, 1989 and Novabour *et al.*, 2003).

Regarding, vitamin E (α- tocopherol), it's appeared to play a major role in chloroplastic antioxidant network of plants. It's being finely regulated depending on the severity of the stress sensitivity. Therefore, it contributes to preservation of an adequate redox station in chloroplasts, and to maintaining thylokoid membrane structure and function during plant development, and in plant responses to stress (Munne-Bosch and Alegra, 2002; Sattler *et al.*, 2004 and Munne-Bosch, 2005). Interestingly, the more positive response of tocopherols to Se under high light conditions in summer suggested that Se contributed to defense ability of plants against increased production of oxygen radicals due to enhanced photosynthesis, however, without added Se, tocopherols started to diminish at vegetative phase, whereas plants supplied with Se maintained an increasing trend (Hartikainen., 2002).

There is some evidence that salicylic acid may be involved in heat stress responses in plants. Exogenous application of salicylic acid and calcium improved plant tolerance to heat stress and increased the accumulation of chlorophylls (Dat *et al.*, 1998 and Larkindale and Knight 2002). Furthermore, SA can be used as a plant hormone (Elad, 1992) and it has a beneficial effect for catching the abundant reactive oxygen species (ROS) that cause cell senescence and loss of plasma membrane permeability and death of cells within plant tissues (Bodannes and Chan., 1979).

The obtained results of Abd-Allah *et al.* (2007) revealed that the highest level (1.0mM) of SA, calcium and ascorbic acid as foliar application improved plant height, dry pod length, number of pods/plant, number of seeds/pod, weight of 100 seeds, dry pod yield/plant, and dry seed yield/plant of common bean cv.Nibrasca, pea cv. Master-B and faba bean cv. Nubaria 1.

Yeast extract are the natural components (contains many compounds, *i.e.*, cytokinins and proteins that enhance cell division and enlargement) which are safe and non-pollutant (Barnett *et al.*, 1990). Also, it contains the haloes-6-phosphate synthase (a key enzyme for trehalose biosynthesis) which not only affects plant development but also improves drought tolerance (Yeo *et al.*, 2000). In this regard, El-Desuki and Nadia (2006) showed that vegetative growth *i.e.*, plant height, number of leaves and branches/plant, leaves area, as well as fresh and dry weight of plants were improved by spraying pea plants with yeast extracts as compared with control. Also, they revealed that pod yield, pod quality and leaf contents of photosynthesis pigments, carbohydrates and cytokinins showed the same trends as vegetative growth aspects.

Therefore, the main objective of the present investigation is to study the influence of some antioxidant substances on pea plants, towards better thermal tolerance and higher productivity under common local environmental condition of early summer season.

MATERIALS AND METHODS

Two field experiment were carried out at Kafr Hassan, Samannoud district, Garbia governorate (10 Km apart of Mansoura city), during the early summer seasons of 2005 and 2006, to study the effect of some antioxidant substances including L- ascorbic acid (V.C.), α-tocopherol (V.E.), salicylic acid (SA), and selenium (Se), as well as yeast extracts and some mineral nutrients i.e. zinc, calcium and their combination, on different performances of pea plants cv. Master-B towards maximizing productivity under moderate heat stress conditions (Table 1).

Experimental design was randomized complete block with three replicates. Seeds of peas were sown, in the moderately moist soil at 15 and 7 February in the two early summer seasons of 2005 and 2006, respectively, in hills, at 10 cm apart on one side of ridges which were 65 cm. widths.

The plot area was 13m² (4 raws, 5m. long and 0.65m. width).

Plants were sprayed three times, 20 days after sowing and repeated every 15 Days, with solutions of the following treatments:

1- Tap water as a control.
2- Vitamin C at concentration of 250 ppm.
3- Vitamin E at concentration of 150 ppm.
4- Selenium at concentration of 50 mg / l in form of sodium selinate.
5- Combination between vitamin E and selenium.
6- Yeast extract at concentration of 25 ml/l.
7- Salicylic acid at concentration of 150 ppm.
8- Calcium at concentration of 2000 mg. /l in form of Ca- citrate (25% Ca.).
9- Zinc at concentration of 100mg. /l in form of Zn-EDTA and Cit (12%Zn.).

10-Combination between calcium and zinc.

All cultural practices were performed as recommended by Hort. Res. Inst.

Representative samples of 5 plants from each plot were chosen at random, 55 days after sowing in both seasons to determine the vegetative growth characters i.e. plant height, number of leaves and branches /plant and fresh and dry weight /plant, as well as, leaf area/plant.

Green pods of two rows of each plot were harvested at the proper maturity stage to determine the following parameters;

1-Average pod length = mean length of 20 pods.

2- Number of green seeds /pod = mean number of seeds /20 pods.

3- Weight of 100-green seeds = mean weight of 1000seeds /10.

4- Fresh pod yield (ton /fed.) =2 rows yield (kg) ×4000÷0.5 plot area ×1000.

Dry pods of other two rows were harvested, counted for determining dry seed yield (ton /fed.).

Total leaf chlorophyll content was determined with A-Minlota SPAD chlorophyll meter (Yadava, 1986) on second leaflet tip (midline).

100g green seeds at the proper maturity stage were taken of each plot to determine vitamin C according A.O.A.C. (1975).

Reducing and non-reducing sugars were determined according to the method of Michel *et al.* (1956). Data were subjected to the statistical analysis and means were compared using new L.S.D. according to Gomez and Gomez, (1984).

Table (1): Monthly means of day and night temperatures during 2005 and 2006 early summer seasons at experimental region.

Month	2005		2006	
	Day (^{0}C)	Night (^{0}C)	Day (^{0}C)	Night (^{0}C)
Feb.	19.64	8.24	20.03	8.69
Mar.	22.21	10.69	22.52	10.27
Apr.	25.83	13.13	26.62	13.13
May	30.32	15.92	29.46	14.78

RESULTS AND DISCUSSIONS

Vegetative growth characters:

Data in Table (2) indicate that, all the applied sprays of used antioxidant substances significantly increased plant height, number of leaves and branches/plant and fresh and dry weight/plant, as well as, leaf area/plant, compared with the control (tap water), during the two seasons.

The tallest plants with more branches and leaves, and heaviest fresh and dry weight of plant, and largest leaf area/plant were obtained from plants treated with Ca and Zn combination, followed by salicylic acid and yeast extract applications in the two seasons.

Table (2): Plant height, number of branches and leaves/plant, fresh and dry weight/plant and leaf area/plant as affected by antioxidant substances in 2005 and 2006 seasons.

Characters / Treatments	Plant height (cm)		No. branches/ plant		No. leaves/ plant		Plant Fresh weight (g)		Plant Dry Weight (g)		Leaf area /plant (cm^2)	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
Control	30.77	30.40	1.20	1.52	12.27	15.47	11.27	11.87	3.42	3.23	20.15	22.85
Vitamin C	31.60	32.47	1.27	1.91	12.33	16.67	14.87	15.27	4.00	3.89	21.29	24.26
Vitamin E	31.67	34.22	1.28	2.07	13.13	17.20	13.30	13.22	3.67	3.60	22.77	25.48
Selenium	32.17	34.53	1.38	2.18	15.45	18.13	13.27	13.87	3.83	3.69	24.63	26.00
V E+ Se	33.23	35.47	1.40	2.22	13.80	18.27	13.67	14.93	3.92	3.81	27.01	26.78
Yeast	31.87	34.47	1.40	2.61	13.23	17.68	18.13	16.13	4.37	3.93	29.40	27.35
S.A	32.93	35.37	1.40	2.62	13.28	19.05	18.25	16.93	4.42	4.35	32.66	32.09
Calcium	33.73	35.68	1.47	2.76	14.87	18.93	15.01	15.33	4.11	3.87	32.15	29.68
Zinc	34.20	36.49	1.49	2.81	15.07	19.50	17.27	15.80	4.21	3.93	32.60	31.39
Ca+ Zn	35.83	36.60	1.50	2.83	16.08	19.16	18.47	17.40	4.48	4.23	32.72	32.51
L.S.D	0.29	0.15	0.02	0.05	0.07	0.17	0.06	0.10	0.12	0.03	0.07	0.11

These results were in conformity with those obtained by Dat *et al.,* 1998; Larkindale and Knight, 2002; El-Dosuki and Nadia 2006; Abd-Allah *et al.,* 2007 and Fathy and El-Hamady, 2007. In this regard, Rivero *et al.* (2004) reported that high temperature stress decreased tomato shoot weight and the activity of some antioxidant enzymes.

Such beneficial effects of mentioned treatments above control, may be due to function of Ca as a second messenger in the signal conduction between environmental factors and plant responses in terms of growth and development. Also, Zn activates auxin and gibberellins synthesis, and consequently, achieved cell division and enlargement. Moreover, the role of Zn as a protective defense against adverse effects of higher temperature (Table 1) via antioxidants and gene regulatory functions (Suge *et al.,* 1986; Cakmak and Marschner, 1988; Chesters, 1992 and Marschner, 1995). In addition, the role of SA as a plant hormone and plays an essential role in the regulation of plant growth and development (Raskin, 1992).

Also, improving plant growth aspects by V.C. treatment may be through enhancing the accumulation of chlorophyll and its act as a co-factor for synthesis of gibberellins and the control of cell growth (Mattagajasingh and Kar, 1989 and Smirnoff and Wheeler, 2000). Moreover, vitamin C is an important buffer against the high oxidative load that accompanies rapid metabolism, also it plays a more active role in which tissue contents affect development via hormonal signaling path ways and modulation of defense networks (Gabriela *et al.,* 2003).

Increasing of α-tocopherols level contributes to plant stress tolerance, while decreasing its level favor oxidative damage (Munne′-Bosch, 2005).

Furthermore, selenium also, plays an important role through its antioxidative function, where it may delay plant senescence and promote plant growth (Hartikainen., 2002).

Regarding, yeast extract, it enhances cell division and enlargement via it contains many components, *i.e.,* cytokinins, enzymes, vitamins and amino acids, which affect plant development and improve stress tolerances (Yeo, *et al.,* 2000).

In contrast, heat stress (Table 1) normally decrease the duration of developmental phases leading to smaller organs (as shown in control application), reduced light perception and carbon assimilation processes including transpiration, photosynthesis and respiration (Stone, 2001).

Yeilds and their components:

It was clearly, noticed that all the obtained results were significantly affected by using antioxidants substances as foliar application compared with untreated one through the two studied seasons (Table 3). Since, the combination between calcium and zinc treatments increased all the studied characters, *i.e.,* pod length, number of seeds/pod, weight of100 green seeds and fresh and dry seed yields, followed by, yeast extract for pod length, SA for number of seeds/pod, calcium and zinc as for weight of 100 green seeds and calcium, zinc and SA as for fresh yield. These results coincided with those of Gupta *et al.* (1999); Kasturikrishna and Ahlawat (2000); Thapa *et al.* (2003); El-Dosuki and Nadia (2006); and Abd Allah *et.al.,* (2007) on pea plants; Fathy and El-Hamady (2007) on cow pea and Fathy and Khedr(2003) on sweet pepper.

These results may be due to the role of antioxidants in enhancing vegetative growth of pea plants (Table 2), since reproductive growth triggers a switch in partitioning from vegetative growth sinks to reproductive sinks.

Table (3): Pod length, number of seeds/pod, weight of 100. seeds, fresh pod yield and dry seed yield as affected by antioxidant substances in 2005 and 2006 seasons.

Characters / Treatments	Pod Length (cm)		No. Seeds/ Pod		Weight of 100 green Seeds (g)		Fresh pod yield (ton/Fed.)		Dry seed yield (ton/Fed.)	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
Control	8.33	8.88	6.97	6.52	34.67	35.67	2.782	2.818	0.657	0.677
Vitamin C	8.83	9.05	7.47	7.17	36.63	38.00	3.125	3.329	0.678	0.722
Vitamin E	8.53	9.07	7.03	6.77	35.67	37.25	3.056	3.378	0.744	0.745
Selenium	8.57	9.27	7.07	6.78	35.85	37.50	3.214	3.396	0.757	0.776
V E+ Se	8.77	9.34	7.47	7.03	36.00	37.92	3.274	3.445	0.790	0.825
Yeast	8.96	9.34	7.27	6.95	36.50	38.67	3.362	3.500	0.829	0.850
S.A	8.82	9.53	8.21	7.46	36.33	38.83	3.517	3.700	0.880	0.884
Calcium	8.87	9.45	7.73	7.20	36.67	38.50	3.449	3.595	0.856	0.923
Zinc	9.24	9.50	8.17	7.23	36.69	38.86	3.483	3.674	0.864	0.955
Ca+ Zn	9.33	9.56	8.29	7.83	36.78	38.90	3.621	3.768	0.884	0.978
L.S.D	0.03	0.01	0.05	0.06	0.05	0.09	0.017	0.022	0.009	0.012

On the other hand, the inhibitory effect of high temperature condition (Table 1) on yields and their components may be due to the serious physiological oxidative stress of elevated toxic level of ROS, thereby, more destructive and degradable effects on the whole biosynthetic machinery under such conditions. (Dichnson *et al.*, 1991; Cakmak and Marschner, 1992). In this respect, Guilioni, (1998) on pea plants, reported that severe heat stress caused a rapid interruption of reproductive organs development while milder stress anticipated the normal termination of phytomeres production by the apical meristem, thereby, the final seed number was linked to a change of source/sink relationships at the plant level. Also, brief exposure of grain legumes to high temperatures during seed filling can accelerate senescence, diminish seed set and seed weight, and reduce yield (Siddique *et al.*, 1999).

Chemical constituents:

Data in Table (4) illustrate that green seed contents of ascorbic acid, reduce and none-reduce sugars, as well as, leaf chlorophyll contents were greatly affected by all treatments compared with the control, in the two seasons. Ascorbic acid, the interaction between Ca and Zn, SA and the combination of V.E and Se were superior in their effects on all mentioned characters followed by calcium, zinc and yeast treatments. The significant increments in the obtained characters over control may be due to the protective and recovered specific transporter enzymes and/or the whole machinery under stress conditions (Palta, 1990). Furthermore, increasing chlorophyll contents may be due to activating antioxidant enzymes via the stimulative effects of Ca, SA, Se, yeast extract and vitamins C and E under such environmental conditions (Dat *et al.*, 1998, Larkindale and Knight 2002, Shang QingMao *et al.*, 2005 and El-Dosuki and Nadia (2006). In this regard, Fathy and Khedr (2005) mentioned that the frequent foliar application, on tomato plants, with amino acids, Zn-citrate and phyto extract (yeast) individually or in combination had beneficial effects on the metabolic potential for synthesis of amino acids, proteins, sugars and carbohydrates, as well as, their antioxidant defensive function, finally, corresponding with normal growth and high yielding capacity. Also, Cakmak *et al.* (1989) reported that zinc application on bean plants enhances synthesis and translocation of amino acids and sugars.

Table (4): Ascorbic acid, reducing and non-reducing sugars and leaf chlorophyll contents as affected by antioxidant substances in 2005 and 2006 seasons.

Characters / Treatments	Ascorbic acid (mg/100g fresh Weight)		R. Sugars (mg/100g fresh Weight)		N. R. Sugars (mg/100g fresh weight)		Leaf chlorophyll content (SPAD UNITS)	
	2005	2006	2005	2006	2005	2006	2005	2006
Control	17.650	18.120	2.731	2.844	10.683	10.878	44.779	45.401
Vitamin C	20.020	21.420	2.822	2.920	10.980	11.123	47.462	48.207
Vitamin E	17.860	18.960	2.688	2.883	10.813	10.967	45.808	45.657
Selenium	18.070	18.530	2.722	2.901	10.708	10.911	45.979	45.830
V E+ Se	18.490	19.100	2.795	2.934	11.067	10.999	47.160	46.673
Yeast	18.827	20.760	2.664	2.998	10.887	11.076	45.501	45.480
S.A	19.850	17.460	2.888	3.061	11.125	11.300	47.359	47.139
Calcium	19.460	19.900	2.928	3.075	11.237	11.210	46.470	46.359
Zinc	19.000	20.340	3.002	3.086	11.183	11.391	46.352	46.117
Ca+ Zn	20.350	21.000	3.025	3.097	11.412	11.458	47.560	47.851
L.S.D	0.107	0.043	0.064	0.006	0.004	0.003	0.094	0.036

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استخدام بعض مضادات الأكسدة لزيادة تحمل الاجهاد الحراري وتحسين انتاجية البسلة تحت الظروف المحلية في العروة الصيفية المبكرة

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نظرا لتزايد المساحة المنزرعة من البسلة صنف ماستر بى فى محافظات الدلتا، فى العروة الصيفية المبكرة خلال شهر فبراير؛ من أجل إطالة موسم انتاج المحصول الطازج، وكذلك الحصول على المحصول البذرى، مما يعرضها لظروف الحرارة المرتفعة أثناء مراحل النمو المختلفة؛ لذلك أجريت هذه الدراسة في قرية كفر حسان مركز سمنود غربية (تبعد ١٠ كم عن مدينة المنصورة)، خلال موسمي الزراعة الصيفى المبكر ٢٠٠٥و ٢٠٠٦، وذلك لدراسة تأثير الرش ببعض مضادات الأكسدة؛ من أجل زيادة تحمل الإجهاد الحراري، وتحسين انتاجية البسلة صنف ماستربي تحت الظروف المحلية في مثل هذه العروة.

استخدمت المواد التالية رشاً على النباتات ثلاث مرات بعد ٢٠ يوم من الزراعة ثم كل ١٥يوم:

١- فيتامن ج (٢٥٠ ملجم/ اللتر). ٢- فيتامين هـ (١٥٠ملجم /لتر). ٣- سيلينيوم (٥٠ ملجم/لتر).
٤- كالسيوم (٢٠٠٠ ملجم/لتر). ٥- زنك (١٠٠ملجم/لتر). ٦- مستخلص خميرة (٢٥مل/لتر).
٧- خليط من السلينيوم وفيتامين هـ. ٨- خليط من الكالسيوم والزنك. ٩- حمض الساليسيلك (١٥٠ ملجم/لتر).
١٠- كنترول (ماء الصنبور).

أوضحت النتائج ان استخدام المواد المذكورة كان له أثر كبير فى زيادة تحمل النباتات للاجهاد الحرارى، وقد ظهر ذلك فى تفوق قياسات النمو الخضرى وكذلك المحصول ومكوناته وجودة القرون ووزن ١٠٠ بذرة طازجة وجودتها فى محتواها من فيتامين ج والسكريات المختزلة والغير مختزلة، وكذلك ازداد محتوى الاوراق من الكلوروفيل وذلك بالمقارنة بالكنترول، وكانت أفضل المعاملات على التوالى هى الكالسيوم+الزنك ، زنك ، كالسيوم ، حمض الساليسيلك، فيتامين ج ، سيلينيوم+ فيتامين هـ ، مستخلص الخميره ، سيلينيوم واخيرا فيتامين هـ.

كان هناك ارتباط ايجابى بين السعة المحصولية وجودة القرون ووزن ١٠٠ بذرة طازجة، وكذلك جودة البذرة فى محتواها من فيتامين ج والسكريات، وعلى الجانب الاخر كان هناك تأثير سلبى لتعرض النباتات الغير معاملة (الكنترول) للاجهاد الحرارى على الصفات المذكورة؛ مما ادى الى نقص واضح فى إنتاجها خلال موسمى التجربة.

فى ضوء هذه النتائج يمكن تحسين تحمل نباتات البسلة للحرارة تحت ظروف العروة الصيفية المبكرة، وذلك باستخدام هذه المواد رشاً على النباتات ثلاث مرات بالتركيزات وفي المواعيد المذكورة؛ للحصول على اعلى انتاجية تحت الظروف المماثلة لظروف البحث.