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EFFECT OF SOME NUTRIENTS AND GROWTH SUBSTANCES ON PRODUCTIVITY OF EGGPLANT (*Solanum melongena* var *esculenta*) GROWING UNDER HIGH TEMPERATURE CONDITIONS

BY

Khedr, Z.M.A.*; Fathy, El-S.L. El-S. and A.M. Moghazy****
* Agric. Botany Dept. of, Fac. Agric. Moshtohor. Zagazig University
** Vegt. Dept.; Hort. Inst. Agric. Res. Centre, Cairo. Egypt

ABSTRACT

Field experiments were conducted at El-Baramoon, Res. Station, Hort. Res. Inst. during the late summer seasons of 2001 and 2002. Eggplants were sprayed with 50 mg/l B in form of boric acid, 100 mg/l Zn inorganic form and 2000 mg/l Ca inorganic form, as well as 25 mg/l GA_3 (growth regulator) and 20 g/L glucose, one month after transplanting. Treatments were done separately as well as their different combinations. Spraying was repeated 3 times with intervals of 20 days after the first one.

The main results obtained could be summarized as following:

The combination of calcium and GA_3 in both seasons gave the highest significant increases of all measured vegetative characteristics (plant height, No. of leaves and branches). On the other hand, earliness of flowering showed its maximum value with the combination of zinc with sugar. Also, of interest that the same treatment gave the highest significant increases of each of percent of fruit setting, yield/plant per area and per feddan, as well as fruit diameter and dry matter percent of fruit. These results were nearly the same in both seasons. Furthermore, the same treatment showed priority to increase different estimated bioconstituents.

As for seed yield of the second part of this study, it was evident that different aspects of seed yield expressed as seed yield either per plant or feddan, weight of 1000 seeds and seed germination percentage were mostly affected with applied treatments. In this respect calcium, calcium + GA_3 and calcium + sugar gave the highest values regarding seed yield and its characteristics.

INTRODUCTION

Eggplant is a staple, public and common in food dishes that originated in Egypt as well as in Southern Europe, North Africa and also has found its way into the American diet from several cultures, (Hewedy *et al.*, 1996a and Russo, 1996).

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Eggplant known to be subjected to adverse effects of high temperature when day and night temperatures are exceeded 20/25°C (Wien, 1997). In the last few years this was the case in Egypt, since extreme high temperatures were prevailed during late summer months. Consequently, eggplant chlorosis, abscission of chlorotic mature leaves and flowers, poor fruiting and bad fruit quality (heat stressed plants) were frequently observed during this period (Fathy *et al.*, 2003).

Recently, it was demonstrated that an internally inducible stress known as oxidative one, the internally generated reactive oxygen species (ROS, toxic oxygen free radicals), those were the main factor beyond all the heat and other stresses related disturbances. Also, it was stated that ox. stress tolerance considered as an important factor for all stresses tolerability (Cakmak and Marschner, 1992 and Mckersie *et al.*, 1996).

Higher temperature stress either accelerate the formation of toxic. ROS within plant tissues or impair the normal defense mechanisms that protect tissues from ROS toxic effect. Such stress induce higher O_2 photo reduction within chloroplasts or electron transport disturbance, and donation of electron to O_2 within mitochondria, all led to generation of toxic ROS.(Bowler *et al.*, 1992; Elstner and Osswald, 1994, and Mckerise *et al.*, 1996). Those ROS (H_2O_2, OH, O^-_2, ...) damaged chloroplast, reduced carbohydrate synthesis and exportation and hastened oxygen senescence (Dicknson *et al.*, 1991), 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, finally senescence and death of cells and tissues, hence, stimulate flower abortion and reduction of yielded fruits (Stroev 1989; Diknson *et al.*, 1991; Cakmak and Marschner, 1992 and Taiz and Zeiger, 1998).

More recently, groups of naturally occurring or exogenously applied substances known as antioxidants or oxygen free radical scavengers were used. In this respect, (El- Ghamriny *et al.*, 1999; Arisha, 2000 (Vita. C), Fathy *et al.*, 2000 (Vita. A & C from carrot extract); EL-Lithy *et al.*, 2001 (Vita. C); Fathy *et al.*, 2003 (citric acid)) all were concerned with other eggplant vegetables. Also Hewedy *et al.*, (1996 a & b) were concerned with the effect of some minerals and stimulators on eggplant.

In the present study, Boron, Zinc, Calcium, glucose and gibberellic acid were applied. In this respect boron is one of nutrients that are important in energy storage or structural integrity including sugar transport, cell wall synthesis, lignification and cell wall structure; carbohydrate, IAA and phenol metabolism and respiration (Loomis and Durst, 1992; Shelp, 1993 and Bondok, 1996).

Also, zinc plays both a functional, catalytic (Vallee and Auld, 1990) and structural role in enzyme reactions (Coleman, 1992; Vallee and Falchuk, 1993 and Utsusomiya and Muto, 1993). In this respect the role of zinc in protein molecules especially the regulation of gene expression was investigated (Coleman, 1992). In addition, many zinc-dependent enzymes are involved in carbohydrate metabolism (Kitagishi and Obata 1986) as well as its essential role in auxins and its precursor tryptophan biosynthesis (Domingo *et al.*, 1992). Beside its requirement for maintenance of integrity of biomembranes, (Pinton *et al.*, 1993). Moreover, zinc plays a key role in controlling (scavenging) both generation as well as detoxification of free oxygen radicals. In which that led to, potentially damaging of membrane lipids, photo-oxidation in chloroplasts, disturbances electron transport in mitochondria, electrolyte leakage from vacuoles and distruction of protein synthesis in ribosome's (Brown *et al.*, 1993, Marschner, 1995 and Mckerise *et al.*, 1996).

As for calcium, in recent years, 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 the cellular level (Marschner, 1995 and Sanders *et al.*, 2002).

Of the other materials being used in the present study were sugar and the growth regulator gibberellic acid. Since, glucose the common source of sugars is an energy – related organic compound and also for racing the early and argent sugars requirement for flowering and fruit setting (Mukherjee *et al.*, 1991 and Takeda *et al.*, 2001). While, gibberellic acid as a phytohormone plays an important role in the sink- source relationships as well as on the tolerability of plants to endure stress conditions such as high or low temperatures (Gadallah, 1999).

Therefore, it was the objective of the present study how to improve the vegetative growth and minimize flower abortion and increase of fruit setting and yield as well as their content of seeds under stress of the high temperature of late summer season. That, by using the more physiologically active materials, i.e. Boron, Zinc and Calcium elements, glucose as a rich source of energy and the growth regulator Gibberellic acid (GA_3).

MATERIAL AND METHODS

Two field experiments were conducted during late summer seasons of 2001 and 2002, to study the effect of some mineral nutrients i.e. Boron, Zinc and Calcium, the growth regulator Gibberellic acid and the common source of energy i.e. Glucose and some of their combinations on eggplant Cv. Black Buety.

Seeds were sown in foam trays filled with peat + vermiculite (1:1) and enriched with nutrients. Seedlings were transplanted at 45 days after sowing (end of April) in rows on one side of ridge 3m long and 0.8m width, at 0.4m apart with 4 ridges per area (9.6m^2).

Treatments were as following:

1- B at 50 mg/l in form of Boric acid (16% B).
2- Zn (chelated-Zn) at 100 mg/l in from of Zn- EDTA (14% Zn).
3- Ca (chelated-Ca) at 2000 mg/l in from of Ca- citrate (20% Ca).

4- GA_3 at 25 mg/l 5- Glucose (Sug.) at 20 g/l

6- The combinations of B + Zn, B +Ca, B+ GA_3, B + Sug., Zn + Ca, Zn + GA_3, Zn + Sug., Ca + GA_3, Ca + Sug., GA_3 + Sug., B + Zn + Ca + GA_3 + Sug. and unsprayed plants as control. These individual treatments were used in combinations at the same concentrations. RCB design of 3 replicates was adopted; each replicate contained 17 treatments.

Plants were sprayed 4 times first at 30 days after transplanting and repeated each 20 days interval. All cultural practices were performed as recommended.

A- Vegetative growth parameters:

Representative 5 plants from each area were taken 95 days after transplanting for determination of plant height (cm), number of leaves and branches/plant.

B- Chemical constituents:

At the same stage samples of 4th leaves were taken from plants of each area and used for the following chemical analysis:

(1) Photosynthetic pigents:

Chlorophyll *a*, *b* and carotenoids were determined spectrophoto-metrically according to the method of Nornal (1982), and calculated as mg/g fresh weight.

(2)Minerals concentration:

N, K and P were determined according to the methods of Horneck and Miller (1998); Horneck and Hanson (1998) and Cotton (1954), respectively.

(3) Bio- constituents:

Total carbohydrates were determined according to the method of Michell *et al.*, (1956) and total phenols by the method of Snell and Snell (1953).

C- Flowering behavior:

Earliness of flowering were recorded as well as fruit setting (%): was calculated from number of flowers and fruits which were taken from 25% marked plants of area, then calculated

$$\text{As :} \quad \frac{\text{No. of fruits/plant}}{\text{No. of total flowers/ plant}} \times 100$$

D- Fruit yield and its components:

Fruit yield and its components were recorded from the plants of two rows of 4.8m² area.

Number and weight of fruits from the cumulative harvesting all over the season of the area (4.8m^2) were recorded and used to calculate the following:

1- Fruit number/plant. 2- Average fruit weight (g.).

3-Fruit yield (kg)/ plant. 4- Total yield (Ton)/ Fed.

5- Relative yield (%) calculated by the equation of:

$$RY\,\% = \frac{\text{Yield/plan t of the treatment}}{\text{Yield/plan t of control}} \times 100$$

6- Fruit length and diameter (cm) and fruit dry matter content (%). were determined from the middle season harvested fruits.

E- Seed yield and its components:

Those were taken from the remainder two rows (4.8m^2 area) of the area. Only first 4 fruits of plant per area (4.8 m^2) were left and then harvested successively at the seed stage (over ripe senescence fruits) seeds were manually extracted.

Number and weight (g.) of seeds/ fruit, seed yield as (g.)/plant, or (Kg)/ area and total seed yield (Kg)/ Fed., seed index wt. of 1000 seeds (g.), seed germination (%) were determined.

All obtained data were subjected to analysis of variance test and significant differences among means were calculated according to the Duncan's multiple range test, Duncan (1955). Also, day and night temperatures during the whole period of experiment (two seasons) were presented as shown in Figs. (1&2).

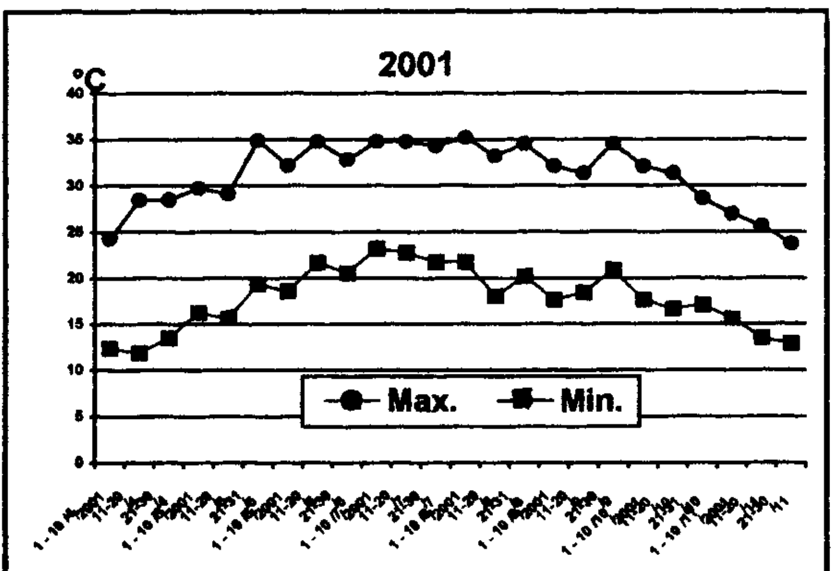

Fig. (1): Temperature during 2001

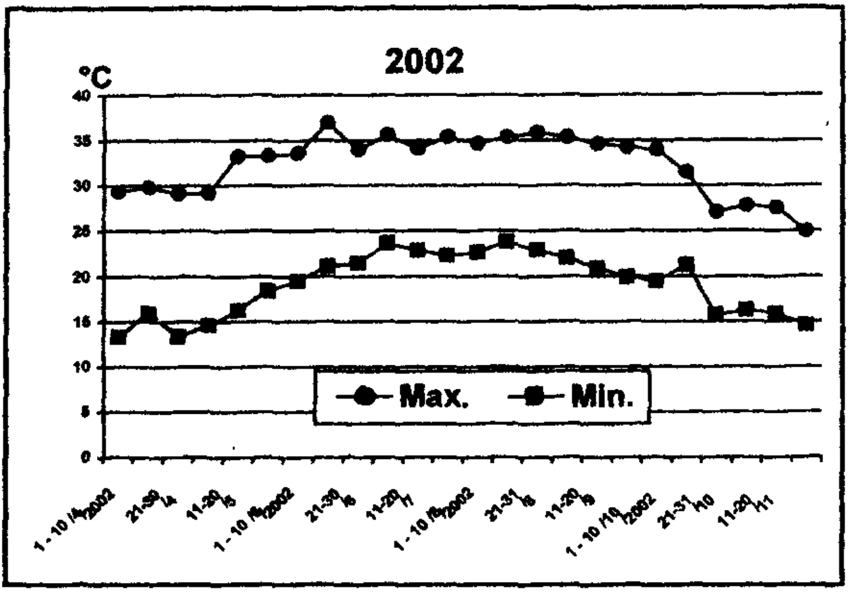

Fig. (2): Temperature during 2002

RESULTS AND DISCUSSION

A-Vegetative growth characters:

Data in Table (1) show that plant height was significantly affected by all tested treatments during both seasons of study. In this respect, irrespective of treatments of Zn alone or combined with either Ca or GA_3 which reduced plant height compared with the check treatment (unsprayed one) all the other treatments significantly increased the plant height. In this regard, the highest values were recorded in case of spraying plants with Ca combined with Sugars during both seasons of study.

Regarding the number of leaves per plant, it was affected by different spraying treatments during both seasons of study. In this respects, the highest increase was achieved by spraying plants with Ca x Sug. in both seasons. On the other hand, treatment the plant with B x Ca, Zn x Sug. and Zn x Ca, resulted in significant reduction in leaves number/plant.

As regards the number of branches per plant, data in the same table revealed that most of studied treatments significantly increased, except that treatments of Ca x GA_3 which led to a significant reduction during the two seasons, compared with the control was observed.

The above mentioned results clearly indicate that the treatment of calcium combined with sugar gave the highest values concerning plant height, number of leaves and of branches per plant in the two assigned seasons, was observed.

Table (1): Effect of different applied materials (B, Zn or Ca; Sugar and GA_3) and their combinations on some growth characters of eggplant during 2001 and 2002 seasons.

Treatment	2001			2002		
	Plant height cm.	No. of Leaves/ plant	No. of branches/ plant	Plant height cm.	No. of Leaves/ plant	No. of branches/ plant
B 50 mg/l	91.43 B	81.20 C	7.13 EFG	77.77 B	70.43 D	6.17 F
Zn 100 mg/l	69.73 FG	65.60 EF	9.10 CD	62.83 EF	50.80 GH	8.13 C
Ca 2000 mg/l	90.43 B	87.10 AB	12.70 A	76.90 B	74.80 C	9.67 B
GA_3 25 mg/l	79.47 CD	56.23 G	7.13 EFG	77.57 B	48.93 HI	6.47 E
Sugar 20 g/l	84.20 C	85.53 BC	8.03 DC	71.67 C	78.53 B	7.07 D
B x Zn	72.97 EF	69.57 DE	9.40 C	63.50 DE	60.50 E	8.17 C
B x Ca	80.63 CD	46.67 H	7.50 EF	68.50 C	41.97 K	6.50 E
B x GA_3	81.60 CD	62.60 F	6.40 FGH	69.37 C	52.07 G	5.90 FG
B x S	90.87 B	67.73 DE	11.47 B	77.23 B	57.5 F	9.80 B
Zn x Ca	66.63 GH	52.63 G	9.27 C	59.97 EF	47.47 IJ	8.07 C
Zn x GA_3	63.27 H	67.33 DEF	9.10 CD	58.20 F	51.30 G	8.03 C
Zn x S	72.40 EF	51.97 G	7.10 EFG	62.90 EF	46.0 J	6.07 F
Ca x GA_3	91.73 B	70.77 D	5.60 H	78.0 B	60.17 E	5.0 H
Ca x S	98.27 A	90.80 A	13.40 A	83.57 A	88.80 A	12.07 A
GA_3 x S	77.80 DE	88.0 AB	9.30 C	67.67 CD	77.20 B	8.30 C
Mix	84.67 C	70.80 D	6.23 GH	71.93 C	61.13 E	5.67 G
Control	70.77 FG	55.63 G	6.07 GH	16.57 EF	46.07 J	5.13 H

The same letter(s) are not significantly difference.

This increase in growth parameters could be attributed to the physiological role of Ca, since calcium participates in cell wall and plasma membrane formation, thereby, increasing their hardiness and protein metabolism and transportation as well (Hepler and Wayne, 1985; Ferguson and Drobak, 1988 and Marshener, 1995). Besides, sugar act as a source of energy for different physiological reactions; it also participates in osmoregulation of the plant cells (Mukherjee *et al.*, 1991 and Takeda *et al.*, 2001). The vigorous growth of eggplant that existed with calcium treatment could be attributed to its key role as a regulator of many cellular functions (Bush, 1995). Since Ca^{2+} generally acts as a protective in reducing the rate of plant senescence and fruit ripening by: (a) a reduction or delay cell wall breakdown. (b) maintenance of membrane function. (c) maintenance of pools both inside and outside the cell that allow retention of the capacity for signal transduction. Thus, we can conclude that Ca^{2+} may have quite opposite effects on senescence, depending on whether protection and maintenance of normal cell metabolism, or collapse of cellular Ca^{2+} regulation, is manifest. The latter situation would be contingent on earlier events in senescence. That finally could be reversed into vigorous growth of treated plants (Ferguson and Drobak, 1988). So, the interaction effect of Ca with sugar may have a role in diminishing the harmful effect of heat stress on eggplant under the high temperature of late summer season.

B-Chemical constituents:

1- Bioconstituents

With regard to photosynthetic pigments, data in Table (2) show that during the two assigned seasons, all applied treatments showed significant increase in leaf pigments concentration (chl. a & b) compared with the check treatment. In this respect, the highest values of chl. *a,b* and *a + b* were achieved in case of Zn combined with Sugar. The same trend was also obtained regarding total carotenoids concentration. This increasing effect may be due to Zn in which act as antioxidants and protect the chloroplasts against the formation of toxic ROS levels thereby prevent degradation of pigments, and inhibits the photoxidation of pigments that arise under heat stress conditions during late summer season (Domingo *et al.*, 1990; Brown *et al.*, 1993 and Sorte *et al.*, 2001).

Also, Zn acts as a functional or regulatory cofactor of a large number of enzymes including those participate in photosynthesis efficiency (Brown *et al.*, 1993), hence, carbohydrates synthesis and accumulation.

As for total carbohydrates concentration, it was being increased in most cases with various sprayed treatments relative to control one. The highest value in this respect was obtained by using of Zn combined with Sugar treatment. Of interest to note that, increases of carbohydrates concentration were preceded with the highest concentrations of photosynthetic pigments.

As for the total phenols also Table (2) shows that its content in leaves was significantly increased with different sprayed treatments. In this respect, phenol could be protected the sprayed plants and make them more tolerable for the heat stress of late summer season, that is because phenols act as antioxidants (Mckerise *et al.*, 1996).

2- Mineral concentration:

Data in Table (3) clearly indicate that all treatments significantly increased the N, P and K concentrations in treated leaves compared with the untreated plants in both seasons. In this connection the highest value was obtained when plants treated with zinc combined with sugar. This increase may be attributed to Zn in which it may prevent the formation of free radicals (O_2^- H_2O_2 OH), thereby, the membrane leakage and chlorosis and necroses of leaves. Besides, it may prevent the oxidative degeneration of IAA and consequently increases the level of IAA in plants. Such increase causes an enhancement of plant growth and mineral nutrients uptake and translocation, or partially due to that sugar acts as an osmoregulator in plant cell; the process that participates in enhancing mineral uptake and translocation in plants and consequently the higher concentrations of mineral in plant tissues (Dhakshinamoorthy and Krishnamoorthy, 1989; Cakmak *et al.*, 1989 and Marschner, 1995).

C- Flowering and fruit yield and its components:

As shown in Table (4 & 5) that spraying the plants with boron at 50mg/l, Zn at 100mg/l, calcium at 2000mg/l; gibberellic acid at 25mg/l or 20 g/l sugar as well as their combinations significantly shortened the number of days required for 25% flowering of sprayed plants.

Table (2): Effect of different applied materials (B, Zn or Ca; Sugar and GA_3) and their combinations on photosynthetic pigments and some bioconstituents of eggplant during 2001 and 2002 seasons.

Treatments	2001						2002					
	Chlo a mg/g fresh weight	Chlo b. mg/g fresh weight	Chl.a+b mg/g fresh weight	Carotenoids mg/g fresh weight	Total carbohydrates mg/g dwt.	Total phenols mg/g dwt.	Chlo a mg/g fresh weight	Chlo b mg/g fresh weight	Chlo. a+b mg/g fresh weight	Carotenoids mg/g fresh weight	Total carbohydrae mg/g dwt.	Total phenols mg/g dwt.
B 50 mg/l	1.417 FG	0.856 J	2.273 J	0.492 J	217.0 F	11.36 G	1.415 K	0.854 J	2.269 J	0.491 J	217.0 G	11.49 E
Zn 100 mg/l	1.334 G	0.729 L	2.063 K	0.469 K	216.4 F	11.24 G	1.334 L	0.723 L	2.057 K	0.468 K	212.5 G	11.31 E
Ca 2000 mg/l	1.656 BC	1.120 E	2.776 D	0.818 D	240.6 E	11.73 F	1.663 E	1.118 E	2.781 D	0.818 D	241.0 F	11.55 E
GA_3 25 mg/l	1.473 EFG	0.993 I	2.466 I	0.570 I	197.4 FG	11.62 F	1.461 J	0.992 I	2.453 I	0.570 I	195.9 H	11.54 E
Sugar 20 g/l	1.272 HI	0.734 K	2.008 L	0.411 L	330.9 B	11.23 G	1.269 M	0.731 K	2.000 L	0.412 L	296.6 C	11.26 E
B x Zn	1.713 B	1.188 B	2.901 B	0.891 B	342.3 B	13.51 B	1.714 C	1.187 B	2.902 B	0.891 B	270.3 E	13.49 B
B x Ca	1.512 DEF	1.137 C	2.649 F	0.711 G	271.5 D	12.55 E	1.511 H	1.136 C	2.647 F	0.711 G	178.3 J	12.52 D
B x GA_3	1.574 BCDE	0.610 N	2.184 P	0.319 O	171.8 H	10.33 H	1.773 B	0.609 N	2.382 P	0.318 O	170.5 K	10.54 F
B x S	1.191 IJK	0.639 M	1.830 N	0.365 N	185.3 GH	10.36 H	1.186 O	0.642 M	1.828 N	0.364 N	339.6 B	10.35 FG
Zn x Ca	1.226 HIJ	0.585 P	1.811 O	0.378 M	179.5 GH	11.20 G	1.223 N	0.582 O	1.805 O	0.375 M	185.1 I	11.23 E
Zn x GA_3	1.117 JK	0.575 Q	1.962 M	0.305 P	175.4 GH	10.16 HI	1.116 P	0.575 P	1.691 Q	0.304 P	174.3 JK	10.14 G
Zn x S	1.973 A	1.880 A	3.853 A	0.941A	367.3 A	15.28 A	1.976 A	1.883 A	3.859 A	0.945 A	336.4 A	15.25 A
Ca x GA_3	1.960 A	1.123 D	3.083 C	0.853 C	288.2 CD	13.42 B	1.688 D	1.127 D	2.815 C	0.851 C	287.6 D	13.52 B
Ca x S	1.562 CDE	1.002 H	2.564 G	0.715 F	342.1 B	12.84 D	1.560 G	1.003 H	2.563 G	0.716 F	340.5 B	12.81 CD
GA_3 x S	1.487 EF	1.058 G	2.545 H	0.593 H	285.4 CD	12.88 CD	1.487 I	1.057 G	2.544 H	0.591 H	287.3 D	12.82 CD
Mix	1.642 BCD	1.106 F	2.748 E	0.732 E	295.4 C	13.08 C	1.642 F	1.106 F	2.748 E	0.734 E	292.4 C	13.09 C
Control	1.078 K	0.605 O	1.681 Q	0.279 Q	169.4 H	10.04 I	1.077 Q	0.610 N	1.687 M	0.282 Q	170.8 K	10.06 G

The same letter(s) are not significantly difference.

Table (3): Effect of different applied materials (B, Zn or Ca; Sugar and GA_3) and their combinations on N, P and K concentrations in leaves of eggplant during 2001 and 2002 seasons.

Treatment	2001			2002		
	N %	P %	K %	N %	P %	K %
B 50 mg/l	3.39 I	0.677 E	3.14 G	3.39 DE	0.678 H	3.12 J
Zn 100 mg/l	3.40 I	0.665 E	3.19 G	3.41 DE	0.663 I	3.18 I
Ca 2000 mg/l	4.0 C	0.739 B	3.46 D	3.98 B	0.740 C	3.52 E
GA_3 25 mg/l	3.47 H	0.677 E	3.38 E	3.45 CD	0.677 H	3.36 G
Sugar 20 g/l	3.20 K	0.629 F	3.08 H	3.21 F	0.625 J	3.08 J
BxZn	3.36 J	0.777 A	3.87 B	3.68 C	0.777 B	3.86 B
BxCa	3.67 F	0.725 BC	3.33 E	3.66 C	0.726 E	3.34 G
BxGA_3	2.98 N	0.395 H	2.74 J	2.99 FG	0.396 M	2.75 L
BxS	3.01 M	0.463 G	2.97 I	3.01 FG	0.463 L	2.97 K
ZnxCa	3.04 L	0.469 E	3.15 G	3.02 FG	0.466 K	3.13 J
ZnxGA_3	2.80 O	0.393 H	2.79 J	2.81 G	0.349 N	2.79 L
ZnxS	4.97 A	0.784 A	4.02 A	4.95 A	0.781 A	4.00 A
Cax GA_3	4.04 B	0.721 CD	3.63 C	4.03 B	0.700 G	3.59 D
Cax S	3.92 E	0.713 CD	3.43 D	3.92 B	0.700 G	3.41 F
GA_3xS	3.56 G	0.707 D	3.28 F	3.57 CD	0.703 F	3.24 H
Mix	3.96 D	0.738 B	3.68 C	3.94 B	0.737 D	3.66 C
Control	2.10 P	0.341 I	2.21 K	2.03 H	0.341 O	2.20 M

The same letter(s) are not significantly difference.

The highest earliness existed with the combination of Zn + Sugar followed by boron + Zn, then the mixture of different applied materials, Ca, Ca + GA_3 and Ca + B, respectively. The above mentioned results were of 2001 season, yet, nearly similar results obtained during 2002 season.

With regard to the fruit setting, it could be also noticed that significant results with the different applied treatments were also obtained during 2001 and 2002 seasons. Also, the highest percentage of fruit set was obtained with Zn + Sug. in both seasons. Meanwhile, the treatment of Zn + B gave the second value in this respect.

As for the fruit yield per plant, data in Tables (4 & 5) clearly indicate that fruit number and fruit weight per plant were significantly increased as a result of all the studied treatments compared with the control treatment. In this respect, spraying plants with solution of zinc plus sugars ranks first and reflected the highest increment in number and weight of produced fruits per plant followed by treatment of Zn + B, Ca + GA_3 and Ca + Sugar, respectively. The obtained yield reached 3.15 and 2.99, 3.09 and 2.91 in case of using Zn + Sugar and Zn + B during first and second season, respectively. The superiority of Zn plus sugar in increasing number and weight of fruit per plant may be due to the main role of zinc and sugars upon increasing bioconstituents and N, P, K absorption (Table, 2 & 3) as well as the effect of Zn + Sugar on pollenation, pollen grain development and fertilization which internal increased fruit setting % and fruit development which consequently increased the number and weight of fruits/ plant.

Table (4): Effect of different applied materials (B, Zn or Ca; Sugar and GA_3) and their combinations on flowering and fruit yield of eggplant during 2001 season.

Treatments	Earliness (Days) *	Fruit setting %	Yield /plant (Kg)	Yield /area		Total yield (ton/ Fed)	Relative total yield %	Average weight of fruit (g)	Fruit L. (cm)	Fruit D. (Cm)	D.M% of fruit
				Weight (Kg)	Number						
B 50 mg/l	56.80 DE	74.77 F	2.37 CD	35.55F	129.9FGH	28.44F	109.2	273.7DE	10.76 EFG	8.73 BC	9.14 I
Zn 100 mg/l	58.93 B	76.0 EF	2.30 CD	34.5FG	126.3HI	27.6FG	106.0	273.2CD	10.77 DEF	8.77 BC	9.11 IJ
Ca 2000 mg/l	53.87 H	76.57 EF	2.85 B	42.75C	145.0DE	34.2C	131.4	294.8A	11.47 AB	9.37 ABC	10.33 B
GA_3 25 mg/l	56.90 D	76.50 EF	2.33 CD	34.9FG	133.4FG	27.96FG	107.4	261.6E	10.27 G	8.40 C	9.46 H
Sugar 20g/l	56.47 EF	77.83 CDE	2.30 CD	34.5FG	126.6HI	27.6FG	106.0	272.5CDE	10.70 EFG	8.73 BC	9.06 J
B x Zn	53.0 I	80.74 AB	3.09 A	46.4B	158.1AB	37.12B	142.4	273.5AB	11.43 AB	10.27 E	11.11 B
B x Ca	54.20 H	78.67 BCD	2.74 B	41.1D	140.8E	32.88D	126.3	291.9AB	11.50 A	10.30 A	9.58 G
B x GA_3	58.80 B	76.13 EF	2.28 CD	43.2G	125.6HI	27.36G	105.1	272.3CDE	10.70 EFG	9.63 AB	8.39 L
B x S	56.80 DE	76.37 EF	2.38 CD	35.7F	135.0FGH	28.56F	109.7	264.4DE	10.63 EFG	9.57 AB	8.39 L
Zn x Ca	58.53 B	76.03 EF	2.28 CD	34.2G	125.1HI	27.37G	105.1	273.4DE	10.53 FG	9.50 AB	8.72 K
Zn x GA_3	57.43 C	79.77 ABC	2.34 CD	35.1FG	123.6I	28.08FG	107.8	238.9ABC	11.17 ABCD	10.07 A	8.17 M
Zn x S	51.27 J	81.70 A	3.15 A	47.25A	162.3A	37.8A	145.2	291.1AB	11.47 AB	10.27 A	12.85 A
Ca x GA_3	54.0 H	76.87 DE	2.89 AB	43.35C	150.1CD	34.7C	133.2	288.8AB	11.30 ABC	10.17 A	10.62 C
Ca x S	54.67 G	78.60 BCD	2.88 AB	43.2C	153.6BC	34.6C	132.7	281.2BCD	11.03 BCDE	9.93 A	9.66 F
GA_3 x S	56.33 F	79.47 BC	2.47 C	43.05E	133.9F	29.64E	113.8	276.7CD	10.87 CDEF	9.73 AB	9.54 G
Mix	53.30 I	79.0 BC	2.84 B	42.6C	127.3GHI	34.1C	130.9	334.6A	9.40 H	8.43 C	10.09 E
Control	60.20 A	71.53 G	2.17 D	32.6H	133.8FG	26.04H	100.0	243.6F	9.57 H	7.23 D	7.85 N

The same letter(s) are not significantly difference.

* 25% flowering plants.

Table (5): Effect of different applied materials (B, Zn or Ca; Sugar and GA_3) and their combinations on flowering and fruit yield of eggplant during 2002 season.

Treatment	Earliness (Days) *	Fruit setting %	Yield /plan (kg)	Yield /area		Total yield (ton/ Fed)	Relative total yield %	Average weight of fruit (g)	Fruit. L. (cm)	Fruit D. (cm)	D.M. % of fruit
				eight (kg	Number						
B 50 mg/l	57.7 AB	76.20 CDE	2.25 FG	33.75F	125.6FG	27.0FG	109.2	268.7DE	10.6 E	9.5 CD	9.14 G
Zn 100 mg/l	58.3 AB	76.40 CDE	2.19 GH	32.9FG	117.1H	26.3FGH	106.3	280.9C	11.0 BCD	9.9 BC	9.08 G
a 2000 mg/l	54.4 DE	78.33 B	2.71 C	40.7C	140.1D	32.6C	131.5	290.5AB	11.4 AB	10.3 AB	10.34 D
GA_3 25 mg/l	57.5 ABC	76.27 CDE	2.22 FGH	33.3FG	121.3GH	26.6FGH	107.7	274.5CDE	10.8 DE	9.7 CD	9.47 F
Sugar 20 g/l	57.5 ABC	75.30 DE	2.19 GH	32.9FG	122.5FG	26.3FGH	106.3	268.6E	10.5 E	9.4 D	9.03 G
B x Zn	53.8 E	78.17 B	2.91 B	43.7B	122.4FGH	34.9B	141.3	357.0A	11.5 A	10.4 A	11.08 B
B x Ca	54.7 DE	78.30 B	2.59 D	38.9D	149.4BC	31.1D	125.7	260.4E	11.4 AB	10.3 AB	9.53 EF
B x GA_3	59.1 AB	78.47 B	2.17 GH	32.9G	135.4E	26.3GH	105.3	242.9CD	10.9 CDE	9.8 CD	8.41 I
B x S	57.6 ABC	78.27 B	2.26 F	33.9F	117.3H	27.1F	109.7	289.0BC	11.0 BCD	9.9 BC	8.42 I
Zn x Ca	58.7 AB	75.27 EF	2.16 H	32.4G	120.8GH	25.9H	104.9	268.2CDE	10.8 DE	9.7 CD	8.67 H
Zn x GA_3	57.4 ABC	75.73 DE	2.23 FGH	33.5FG	117.7H	26.8FGH	109.3	284.6BC	10.9 DE	9.7 CD	8.15 J
Zn x S	50.9 F	80.93 A	2.99 A	44.9A	121.4GH	35.9A	145.1	369.4AB	11.4 AB	10.2 AB	12.82 A
Ca x GA_3	54.2 E	77.47 BC	2.74 C	41.1C	154.8B	32.9C	132.9	265.6D	11.5 A	10.4 A	10.61 C
Ca x S	55.2 CDE	78.30 B	2.73 C	40.9C	140.1D	32.7C	132.5	291.9C	11.3 ABC	9.9 BC	9.69 E
GA_3 x S	56.8 BCD	76.97 BCD	2.35 E	35.3E	147.1C	28.2E	114.1	239.9CDE	10.9 DE	9.6 CD	9.53 EF
Mix	54.1 E	78.40 B	2.72 C	40.8C	127.6F	32.6C	132.0	319.7A	9.3 F	8.4 E	10.28 D
Control	59.3 A	73.60 F	2.06 I	30.9H	121.5GH	24.7I	100.0	254.3F	9.4 F	8.5 E	7.79 K

The same letter(s) are not significantly difference.

* 25 % flowering plants.

Concerning the effect of applied treatments on total yield/Fed., treatments gave higher values when compared with control, moreover, fruit yield per feddan was also significantly affected. Since, treatment of Zn + Sug. gave 30.24 and 28.70 ton/Fed. during 2001 & 2002 seasons, respectively. In addition, these values were descendingly decreased to reach 21.89 with each of B + GA_3 & Zn + Ca during 2001 season and 20.74 with Zn + Ca during 2002 season. Meanwhile, other treatments showed intermediate values.

These results were also analogues when this yield counted on the basis of control. Obtained results on total yield are connected with the increasing effect of Zn + Sugars on number and weight of fruit/plant.

Furthermore, different applied treatments positively affected the assigned characteristics of fruit quality. Since, average weight, length, diameter and the dry matter per fruit were significantly increased. In this respect Zn + Sug., B + Ca, B + Zn, Ca + GA_3 were the most effective ones. Other studies also have been reported similar stimulatory effects of zinc upon flowering and yield of eggplant (Dhakshinamoorthy and Krishnamoorthy, 1989; Bid *et al.*, 1993; Ravichandran *et al.*, 1995 and Raj *et al.*, 2001).

It is likely that sugar is also involved in pollen grain development, pollen tube growth and fruit development during seed development (Gahrtz *et al.*, 1996 and Weber *et al.*, 1997). That, when related with the strict role of zinc upon pollination and fertilization process through auxin synthesis being of great importance. Because, that could be lightly interpreted why great number of setted fruits existed in case of zinc + sugar treatment.

D- Seed Yield and its components:

Table (6) clearly shows a significant reduction in seed weight per fruit, with Zn + Ca treatment; the rest of treatments exhibited their significant increase upon this parameter. The treatment of Ca alone, B + Zn, B + Ca, Ca + Sug., GA_3 + S and the mixture of all applied materials gave the greatest values in this respect, meanwhile, Zn alone, B + GA_3, B + Sug. and Zn + GA_3 treatments were less effective ones, but they were most effective than control one.

As for the seed number per fruit, it could be noticed that despite that increase of seed weight/fruit but their numbers were significantly decreased (B. Zn, sugar each alone, B + GA_3, Zn + Ca, Zn + S and Zn + GA_3). On the other hand, the mixture of all applied materials exhibited the highest number of seeds per fruit. The above mentioned results were obtained during 2001 season meanwhile it was to some extend different during 2002 season. These slight differences could be attributed to the environmental variations between the two seasons.

With regard to the total seed yield/plant during 2001 & 2002 seasons; different applied treatments significantly increased this parameter compared to the control except that a reduction was existed with Zn +Ca only in 2001 season.

Table (6): Effect of different applied materials (B, Zn or Ca; Sugar and GA_3) and their combinations on seed yield of eggplant during 2001 and 2002 seasons.

Treatments	2001							2002						
	Seed. Wt. (gm/ fruit)	Seed No./ Fruit	Seed yield (g /plant)	Seed yield (g/area)	Seed yield (kg/Fed.)	Seed index (wt. 1000 seed)	Germination %	Seed. Wt. (g/ fruit)	Seed No./ Fruit	Seed yield (g/plant)	Seed yield (g/area)	Seed yield (kg/Fed.)	Seed index (wt. 1000 seed)	Germination %
B 50 mg/l	11.48 C	2888 EFGH	34.45 C	516.75C	413.4C	3.977 DE	93.10 CD	10.28 CDE	2786 FG	30.84 DE	462.6DE	370.1C	3.693 B	93.63 E
Zn 100 mg/l	9.59 D	2801 GH	28.76 D	431.4D	345.1DE	3.427 F	93.37 D	8.603 F	2611 GHI	25.81 G	387.15G	309.7E	3.297 CD	92.3 H
Ca 2000 mg/l	13.46 A	3226 C	40.39 A	605.85A	484.7A	4.177 CD	96.27 A	12.11 A	3086 DE	36.31 AB	544.7AB	435.7A	3.923 B	95.8 B
GA_3 25 mg/l	11.43 C	2967 EF	34.28 C	514.2C	411.4C	3.853 E	94.70 B	10.44 C	2696 GH	31.32 D	469.8D	375.8C	3.877 B	94.1 D
Sugar 20 g/l	11.87 C	2805 FGH	33.57 C	503.55C	402.8C	3.990 DE	94.0 BC	9.930 DE	2723 GH	29.79 EF	446.85EF	357.5D	3.647 BC	94.0 DE
B x Zn	13.60 A	3514 B	40.79 A	611.85A	489.5A	3.870 E	94.13 BC	11.51 B	3310 BC	34.55 C	518.25C	414.6B	3.840 B	94.1 D
B x Ca	13.70 A	3140 CD	41.09 A	616.35A	493.1A	4.373 BC	96.23 A	12.42 A	2979 EF	37.26 A	558.9A	447.1A	3.170 D	96.57 A
B x GA_3	9.41 D	2901 EFGH	28.21 D	423.15D	338.5EF	3.250 FG	92.40 D	8.03 G	2609 GHI	24.08 H	361.2H	288.9F	3.083 D	92.23 GH
B x S	9.29 DE	2910 EFG	27.88 DE	418.2DE	339.6EFG	3.203 FG	92.57 D	8.07 G	2536 HI	24.21 H	363.15H	290.5F	3.187 D	92.27 H
Zn x Ca	8.92 F	2911 EFG	26.77 F	401.55F	321.2G	3.403 F	92.5 D	8.13 G	2453 I	24.03 H	360.45H	288.4F	3.310 CD	92.73 FG
Zn x GA_3	9.46 D	2778 GH	28.39 D	425.85D	340.7D	3.407 F	93.40 CD	8.29 FG	2659 GH	24.89 GH	373.4GH	298.7EF	3.123D	92.9 F
Zn x S	12.99 B	2742 H	38.96 B	584.4B	467.5B	4.743 A	96.60 A	10.38 CD	3396 B	31.14 D	467.1D	373.7C	3.060 D	95.0 C
Ca x GA_3	11.28 C	3477 B	33.85 C	507.75C	306.2C	3.247 FG	93.77 BC	9.88 E	3120 CDE	29.64 F	444.6F	355.7D	3.167 D	92.2 H
Ca x S	13.75 A	3423 B	41.26 A	618.9A	495.1A	4.020 DE	96.0 A	11.99 A	3265 BCD	36.97 AB	554.55AB	443.6A	3.773 B	95.83 B
GA_3 x S	13.53 A	3029 DE	40.59 A	608.85A	487.1A	4.543 AB	96.27 A	12.25 A	2669 GH	36.75 AB	551.25AB	441.0A	4.657 A	96.33 A
Mix	13.71 A	4207 A	41.13 A	616.95A	493.6A	3.260 FG	92.63 D	11.98 AB	3712 A	35.92 B	538.8B	431.0A	3.227 D	92.37 GH
Control	9.08 EF	2966 EF	27.25 EF	408.75EF	327.0FG	3.063 G	90.10 E	7.96 G	2567 HI	23.88 H	358.2H	286.6F	3.103 D	90.40 I

The same letter(s) are not significantly difference.

Regarding seed yield, in most cases all treatments were over or superiored yielded than control one, either per area or per feddan, obviously different treatments significantly increased these two parameters except their significant reduction only during 2001 season with Zn + Ca treatment.

As regards the weight of thousand seeds, i.e. the seed index, Table (6) clearly shows that a significant increase was the dominant result of each treatment during both seasons except that a reduction during the second season existed with B + GA_3 and Zn + Sugar treatments.

Here, of interest to note that the significant reduction of seed characteristics was existed with Zn + Ca treatment; and a significant increase was only existed in case of seed index.

Lastly, ability of the harvested seeds to germinate was also investigated in the present study. Since, in the two seasons and with various applied treatments; a significant increase in germination percentages was existed. Increases, for example reached to 96.23 & 96.57 with B + Ca in the two seasons, respectively comparing with 90.1 & 90.4 that of control treatment.

In general, increasing of yielded eggplant fruits and seeds production was proceeded with high percentages of fruit setting by the most of the applied treatments. Also, increasing of fruit setting could be attributed to the increase of plant tolerability to the heat stress during the period of late summer months. Thereby, eggplants were grown well under the conditions of most applied treatments. Also, that was proceeded with vigorous growth of transplanted seedlings. So, the final obtained fruit and seed yield being more expectable under the conditions of various applied treatments.

As general conclusion, several studies have been reported the requirement of boron in flowering and seed production. These studies started from the abnormal chromosomal separation during cell division and differentiation in B deficient plants (Bould *et al.*, 1984).

Also, B necessity for regeneration growth (flower and seed production) is much higher than for vegetative growth (Gupta 1993). In addition it was concluded that during pollen germination, pollen tubes absorb B from pistil tissues and thus create a sink for B in the pistil (Robbertse *et al.*, 1990). Moreover, B-deficiency enhanced production of oxygen free radical, impairment of plasma membrane and RNA/ DNA metabolism as well as the reduction of IAA level. Although, B deficiency has been found to alter many metabolism systems and alter the concentration of several amino acids (Marschner, 1995).

Considering zinc element, also as general its deficiency has not been directly attributed to enzyme malfunction, but to diminished activity of enzymes in certain tissues. This lead to a reduction of photosynthesis, decreased starch formation, reduced auxins level, accumulation of amino acids with a decrease in protein synthesis, an increase in permeability of bio-membranes, and inorganic P content, and depression of male fertility. Also, Zn stress depresses synthesis of DNA, which suppresses gene replication and finally cell formation and cell division. In addition, Zn could increase seed yields through the effect on seed formation rather than on seed growth (Brown *et al.*, 1993).

Finally, addition to all that discussed about the role of boron, zinc, sugar; calcium is generally seen as protective in reducing the rate of different pathways leading to senescence and mediate survival responses (Hepler and Wayne, 1985). That is of great interest regarding the ability of treated plants to induce tolerable case to different stresses including high temperature conditions. There are a number of effects that support this seen: a) a reduction or delay in cell wall breakdown. This effect is most usually expressed in a delay in fruit softening associated with polygalacturonase activity. Given, however, that cell wall breakdown is unlikely to be the primary event in ripening or senescence (Grieson and Tucker, 1983), then evolvement of Ca^{2+} here may not be strictly regulatory, but rather fortuitous. b) maintenance of membrane function. This effect would be seen as an extracellular effect, and a consequence of Ca^{2+} binding to the outer surface of the plasma membrane, where, Ca^{2+} can affect phase transition and membrane fluidity (Ferguson, 1984). and c) maintenance of pools both inside and outside the cell that allow retention of the capacity for signal transduction. This effect seems now an important possibility. An implication is that some aspects of senescence resemble those associated with Ca^{2+} deficiency, where pools become depleted and addition of external Ca^{2+} can delay or inhibit senescence (or remedy deficiency) (Ferguson and Drobak, 1988).

As conclusion of this study; the treatments of zinc + sugar followed by boron + gibberellic acid and zinc + calcium each gave vigorous growth and great seed and fruit yield of eggplant during the high temperatures of late summer season. Thereby, these treatments could be recommended to endure the injury effect of high temperature stress and improving seed and fruit yields of eggplant during late summer cultivation under the Egyptian conditions.

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تأثير بعض العناصر ومواد النموعلى إنتاجية نبات الباذنجان النامى تحت ظروف الحرارة المرتفعة

زكريا محمد خضر*، السعيد لطفي السيد فتحي، علي محمد مغازي****
* قسم النبات الزراعي – كلية الزراعة بمشتهر – جامعة الزقازيق
** قسم الخضر – معهد بحوث البساتين – مركز البحوث الزراعية – مصر

أجريت تجارب حقلية خلال الموسم الصيفي المتأخر (موسمي ٢٠٠١-٢٠٠٠) بمحطة البرامون البحثية التابعة لمعهد البساتين على نبات الباذنجان بهدف تحسين النمو وإنتاج الثمار والبذور من خلال تحسين العمليات الأيضية الداخلية للتغلب على ظروف الإجهاد الحراري الذي يحدث في العروة الصيفية المتأخرة. وذلك برش النباتات في عمر ٣٠ يوم بعد الشتل (مع تكرار الرش ٣ مرات كل ٢٠ يوم) وكانت المعاملات كالتالي:

١- البورون (٥٠ ملجم/لتر)
٢- الزنك (١٠٠ملجم/لتر)
٣- كالسيوم (٢٠٠٠ ملجم/لتر)
٤- جبريللين (٢٥ ملجم/لتر)
٥- جلوكوز (٢٠جم/لتر)
٦- **كل التوليفات المحتملة بينهم.**

تم أخذ قياسات النمو وتقدير بعض العناصر المعدنية والمكونات الحيوية وصبغات البناء الضوئي وكذلك قياسات الإزهار ومحصول الثمار والبذور وكانت أهم النتائج كالتالي:

تفوقت معظم المعاملات على في أغلب الصفات المدروسة، حيث أدت إلى تحسين أداء الباذنجان ومحصوله تحت ظروف التجربة. ومن أفضل المعاملات الجلوكوز + الزنك، البورون + الزنك، الجبريللين + الكالسيوم، الجلوكوز + الكالسيوم، حيث أدت إلى زيادة واضحة فى القياسات الخضرية المدروسة وكذلك تأثير ايجابى فى بعض المكونات الداخلية خاصة محتوى الصبغات ومحتوى بعض العناصر المعدنية (NPK) وكذلك بعض المكونات الحيوية كالفينولات وانعكس أثر هذا على التبكير فى الازهار وزيادة المحصول الثمري في موسمي التجربة وكانت أفضل المعاملات فى هذا المجال هى الجلوكوز + الزنك، البورون + الزنك والتى أدت الى زيادة واضحة خلال موسمى النمو (بنسبة ٤٥,٢%، ٤٥,١%)، (٤٢,٤%، ٤١,٣%)، (٣٣,٢%، ٣٢,٩%) على التوالي.

وبالنسبة لمحصول البذور كانت أفضل المعاملات في موسمي التجربة (الكالسيوم + الجلوكوز، البورون + الكالسيوم، الجبريللين + الجلوكوز).

في ضوء هذه النتائج يمكن أن نوصي لزيادة تحمل الحرارة المرتفعة وإعطاء أعلى محصول ثمري برش نباتات الباذنجان بمخلوط الزنك (١٠٠ جزء في المليون) + الجلوكوز (٢٠جم / لتر) ثلاث مرات خلال موسم الزراعة. وكذلك للحصول على أعلى محصول بذرى يمكن رش الباذنجان بمخلوط الكالسيوم (٢٠٠٠ جزء فى المليون) + الجلوكوز (٢٠جم / لتر) ثلاث مرات خلال موسم الزراعة.