J. Agric. Sci. Mansoura Univ., 32 (2): 991 - 1009, 2007

TRIALS FOR IMPROVING GROWTH AND PRODUCTIVITY OF TOMATO (*Lycopersicon esculentum*, Mill.) PLANTS GROWN IN WINTER SEASON.

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ABSTRACT

Growth of tomato plants cv. Castel–Rock grown in winter season under open field conditions during 2004/05 and 2005/06 growing seasons was positively affected by application of boron and zinc each at 50 & 100 ppm, calcium and phosphorus at 250 and 500 ppm for each . Since, significant increase of stem length , number of branches and leaves /plant, total leaf area, fresh and dry weights of both stems and leaves was existed. However, a significant reduction in the assimilation rate was obtained with all applied treatments .

The two applied concentrations of each elements parally increased photosynthetic pigments, minerals (N, P, K,Ca and Mg), sugars, carbohydrates and protein concentrations in leaves when compared with those of untreated plants .

The obtained vigorous growth of tomato with different applied treatments was accompanied by an obvious alteration in many anatomical features of leaves. Here, all applied treatments increased lamina thickness and its comprising tissues, i.e., upper and lower epidermis, palisade and spongy tissues. Besides, thickness of midrib, dimensions of vascular bundle and thickness of phloem and xylem tissues were also increased.

Moreover, the applied element treatments caused earliness of flower anthesis and also increased the number of flowers, percentage of fruit setting, number and weight of fruits /plant. The highest total fruit yield was obtained with Ca at 500 ppm followed by Zn at 100 ppm then B at 100 ppm and Pat 5s00 ppm, respectively. Meanwhile, chemical composition as minerals, sugars, carbohydrates, vitamin C and total soluble solids in tomato fruits were also increased. Therefore, the present study strongly recommend the use of such nutrient elements not only to improve growth but also to increase earliness and total tomato production specially in winter season to avoide all cautions about inserting greenhouses in agricultural system.

INTRODUCTION

A wide gap in tomato production occurs in spring and early summer seasons every year in Egypt . This drop in productivity is linked to prevailing of unconducive cold temperature during December , January and February , besides frost waves, which occur almost annually during such cold season, severe damage of vegetative growth and poor fruit set were the resultant case .

It had been reported that tomatoes injured when exposed to nonfreezing low temperature below 12˚C (Saltveit and Morris, 1990). Also, under local conditions similar fidings about the adverse effects of natural chilling stress (winter and early spring seasons)on growth, flowering and yielding of tomatoes were obtained by Soliman (1992) .

Once again tomatoes and other cold sensitive plants undergoing several adverse physiological events, alterations and disturbances, all of

these are linked to the dramatically restricted growth and fruiting during chilling stress .

Among such disturbances, adverse changes in structural and biochemical properties of photosynthetic and respiratory systems (Macjejwska *et al.,* 1984). Most of the basically ATP generating pathways, i.e., photophosphorylation, glycoiysis, TC-cycle and oxidative phosphorylation are restricted (Ortiz, 1991). Reduction in growth and protein synthesis, depletion in carbohydrate reserves, sever decrease in phosphorus uptake and ATP synthesis as well as accumulation of free toxic NH_4 lead to more expenditure of ATP in sequestering NH_4 into new nitrogen containing compounds (Rabe and Lovatt, 1986). Meanwhile, high demand for ATP is actually fulfilled during the first few days of growth at low temperature (Sobczyk and Kacperska, 1978). Such demand should be very clear and argent in plants of very limited chilling tolerance capacity as tomatoes and cucumber (Sobczyk *et al.,* 1985). Also, cold stress induces high levels of endogenous ethylene led to more stress injurious effect (Wang, 1987).

Recently groups of substances known as antioxidants or oxygen free radical scavengers were exogenously applied to protect against adverse effects of environmental oxidative stress, such as citric acid, ascorbate, glutathione, some mineral elements (Zn &Ca) and vitamins (Fathy *et al.,* 2003, Fathy and khedr,2005 and Wanas, 2006) . In this respect boron is important in energy storage or structural integrity functions including sugar transport, cell wall synthesis lignification and cell wall structure; carbohydrate, IAA and phenol metabolism and respiration (Shelp, 1993 and Bondok, 1996).

Also, zinc plays as a functional, catalytic (Vallee and Auld, 1990) and structural role in enzyme reactions (Utsusmiya and Muto, 1993) . In this respect the role of zinc in protein molecules specially 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 (Dominage *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 and detoxification of free oxygen radicals, in which that lead to potentially preventation of their adverse consequences, i.e. damaging of membrane lipids, photo-oxidation in chloroplasts, disturbances electron transport in mitochondria, electrolyte leakage from vacuoles and distruction of protein synthesis in ribosomes (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 low 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) .

With regard to phosphorus, it is essentially required for ATP synthesis . Also, it was reported that all of the active processes including

synthesis of bio-constituents, mineral uptake , translocation and retention dependent on ATP supply (Mengel and Kirkby , 1982) .

Therefore, present study aimed to ameliorate the adverse effects of low temperature on tomato plants during cold season and to improve their growth, minimize flower abscission and increase fruit setting, yield and quality as well by using some mineral nutrients as boron , zinc, calcium and phosphorus. That, in turn, could be minimized the high costs of production, thereby make of tomato fruits cheap during this period and to avoid all cautions (regarding both environment and human consumption) for inserting greenhouse production in the agriculture system from the another.

MATERIALS AND METHODS

Two field experiments were conducted at the Experimental Farm of the Agricultural Botany Department, Faculty of Agriculture at Moshtohor, Benha University, Egypt during two successive winter seasons of 2004/05 and 2005/06 . Tomato (*Lycopersicon esculentum,* Mill.) cultivar Castel-Rock (that known to be cultivated in Egypt in warm seasons) was taken as a botanical material in this work . Seeds were secured from the Egyptian Agricultural Res, Center, Ministry of Agric ., ARE.

This work was performed in order to improve growth of tomato under natural cold conditions using some nutrient elements , i.e., boron , zinc, calcium and phosphorus. Leaf anatomy , fruit setting as well as yield and fruit quality of tomato plants were also studied.

Treatments were as follows :

1-Distilled water as control treatment .
2-Boron (B) at concentrations of 50&100 ppm in form of boric acid (16% B).
3-Zinc(Zn)at concentrations of 50&100 ppm in form of celeated zinc(14% Zn)
4-Calcium (Ca) at concentrations of 250 & 500 ppm in form of calcium-citrate (25% Ca) .
5-Phosphorus (P) at concentrations of 250 & 500 ppm in form of H_3PO_4 (31.5 %P).

The assinged nutrient elements and their levels as well as distilled water were applied as seed-soaking for 6 hours and as foliar spray at 25 and 50 days after transplanting.

The pre-sowing treated seeds were sown in foam trays filled with peat moss + vermiculate (1:2v/v) and enriched with nutrients. Tomato seedlings aged 35 days (i.e. at 1st January in both seasons) were transplanted in open field at 30 cm apart on one side of ridge (3.5 m length and 80 cm width) with 3 ridges per experimental plot (10.5m^2 area). The experiment was performed as a randomized complete – block design system with 3 replicates. In both seasons, the normal agricultural practices of growing tomato were followed up as recommended.

Sampling date and collecting data :-

I- Vegetative growth characters :

Six plants were randomly chosen form each treatment at 75 days after transplanting in both seasons to estimate growth parameters as stem

length (cm), number of branches/plant, stems fresh and dry weight (g)/plant, number of leaves/plant as well as leaves fresh and dry weight (g)/plant.

Total leaf area (cm^2)/plant was also determined using the disk method as described by Derieux *et al.,* (1973) and the assimilation rate was calculated using the equation of Wareing and Phillips (1981).

$$\text{Assimilation rate (A. R.)} = \frac{\text{Total leaf area (cm}^2\text{) / plant}}{\text{Total leaf dry weight (g)/plant}}$$

II- Photosynthetic pigments : -

Chlorophyll a ,b and carotenoids were determined in tomato leaves at 75 days after transplanting in both seasons according to the method described by Inskeep and Bloom (1985).

III- Chemical constituent in the leaves:

Sample of tomato leaves at 75 days after transplanting were taken to determine total carbohydrates (Dubois *et al.,* 1956), total and reducing sugars (Thomas and Dutcher, 1924), total nitrogen (Horneck and Miller, 1998), phosphorus (Sandell, 1950), potassium (Horneck and Hanson, 1998) and calcium and magnesium (Jackson, 1967) . Also, crude protein was calculated according to A.O.A.C. (1990) using the following equation :

Crude protein = total nitrogen X 6.25

IV- Anatomical study :

According to the wide differences in the morphological characters due to the treatments used, a comparative anatomical studies on leaves of treated plants compared with those of the control were microscopically examined, also, at 75 days after transplanting.

Specimens of leaves ($1cm^2$) were taken from the middle part of the terminal leaflet blade of the 4^{th} apical leaf on the main stem . The specimens were then killed and fixed for at least 48 hours in F. A. A. solution, (10 ml formalin : 5 ml glacial acetic acid : 85 ml ethyl alcohol 70%) washed in 50% ethyl alcohol, dehydrated in series of ethyl alcohols (70 , 90 , 95 and 100%), infiltrated in xylene, embedded in paraffin wax of a melting point 60-63˚C (Sass, 1950), sectioned at 20 μ using a rotary microtome, double stained with fast green and safranin (Johanson, 1940), cleared in xylene and mounted in Canda balsam . The prepared sections were microscopically examined . Counts and measurements (μ) were taken using a micrometer eye piece . Averages of readings from 4 sections/treatment were calculated .

V- Flowering and yield characters

Six plants per each treatments were randomly chosen, labeled and the following data were recorded .

(a) Start of flower anthesis (days) : Expressed as number of days passed from transplanting till the first flower anthesis.

(b) Earliness of flower anthesis (days) : Expressed as number of days that passed between the first flower anthesis in any treatment and the anthesis of first flower in control treatment .

(c) Total number of flower/plant.

(d) Fruits setting percentage : It was calculated according to the following equation :

$$\text{Fruits setting \%} = \frac{\text{No. of fruits/plant}}{\text{No. of flowers/plant}} \times 100$$

(e) Total number of fruits/plant

(f) Total yield (kg)/plant .

(g) Relative total yield :It was calculated as % of control treatment .

VI- Chemical constituent in the fruits:

Sample of tomato marketable sized picked fruits were taken to determine total carbohydrates (Dubois *et al.,* 1956), total and reducing sugars (Thomas and Dutcher, 1924), total nitrogen (Horneck and Miller, 1998), phosphorus (Sandell, 1950), potassium (Horneck and Hanson, 1998) and calcium and magnesium (Jackson, 1967) . Also, crude protein was calculated according to A.O.A.C. (1990) using the following equation :

Crude protein = total nitrogen X 6.25

In addition , in fresh fruits, a hand referactoometer and the method of A.O.A.C. (1990) were used for the total soluble solids (T.S.S.) and vitamin C determinations, respectively .

VI- Statistical analysis :-

Data of vegetative growth, flowering and yield characteristics were subjected to statistical analysis according to Snedecor and Cochran (1980) using L.S.D. test at 0.05 level .

RESULTS AND DISCUSSION

I- Growth behaviour of tomato plants :-

Data illustrated in Table (1) clearly show that different estimated growth parameters of tomato stems (length, branches number, fresh and dry weights / plants) and leaves (number, fresh and dry weights and total leaf area / plant) were significantly increased with all applied nutrient elements compared with those of untreated plants during the two growing seasons. Increases were more obvious with Zn followed by Ca then B, while P ranked the last in this respect. Also, increases were in parallel to the applied concentrations of each element.

Increment of branches number is of great importance, since it could be later accompanied with an increase in formed and yielded fruits. Also, increasing the number of leaves is of great interest because their reflection upon the final photosynthetic area, thereby the net assimilates that could be directed to the developing fruits.

In addition, the calculated assimilation rate (leaf area in cm^2 required for producing one gram of dry matter) may be support the previously mentioned data about vigorous growth of tomato plants as affected by the applied nutrient elements. Since, significant reduction in this parameters was existed with all applied treatments compared with the control one. That could be considered an evidence to increase the efficiency of photosynthesis and also synthesize more assimilates per each unit of leaf area, hence high rate of their translocation specially towards sink sites (formed fruits) .

Table (1): Effect of some nutrient elements on growth behaviour of tomato plants at 75 days after transplanting during 2004/ 05 and 2005 / 06 seasons.

Characters / Treatments (ppm)		Stem length (cm)	No. of branches/ plant	Stems fresh weight (g)/ plant	Stems dry weight (g)/plant	Leaves No./plant	Leaves fresh weight (g)/plant	Leaves dry weight (g)/plant	Total leaf area/cm^2)/ plant	*A.R. cm^2/g
		Season 2004 / 05								
Control	0.00	46.17	4.17	39.98	4.78	26.50	80.02	15.02	2395.88	59.51
B	50	56.50	5.33	49.86	7.40	35.17	96.30	18.08	2783.16	153.94
	100	62.17	6.33	64.44	8.65	41.50	129.14	24.18	3607.12	149.18
Zn	50	65.73	6.00	58.82	8.04	37.87	111.42	20.28	3094.68	152.60
	100	70.33	7.67	81.69	10.74	44.67	166.08	31.34	4511.57	143.96
Ca	250	64.50	6.33	67.16	8.78	34.83	111.30	20.74	3134.34	151.13
	500	67.17	7.17	88.26	11.92	42.67	160.76	30.88	4590.80	148.67
P	250	54.67	5.33	49.38	6.89	33.67	93.62	17.82	2715.86	152.41
	500	60.83	6.00	60.82	8.54	37.33	121.48	23.28	3468.82	149.00
LSD	0.05	5.43	0.73	6.69	1.42	4.06	8.22	1.89	160.54	2.21
		Season 2005 / 06								
Control	0.00	39.67	3.83	32.14	3.84	24.67	71.04	13.16	2120.99	161.17
B	50	54.33	5.00	42.68	6.12	32.50	90.02	16.78	2588.16	154.24
	100	58.83	5.67	59.44	7.69	35.67	118.60	23.52	3441.68	146.33
Zn	50	60.67	5.17	56.82	7.42	33.17	96.66	17.66	2683.22	151.94
	100	67.83	6.50	75.86	10.52	39.83	144.86	28.82	4177.24	144.94
Ca	250	58.17	5.83	54.12	8.12	32.00	106.50	19.98	3087.56	154.33
	500	63.83	6.50	79.94	11.04	40.50	129.20	26.08	3858.22	147.94
P	250	53.17	4.83	41.82	5.88	31.17	84.96	16.08	2487.11	154.86
	500	57.33	5.00	54.18	7.56	34.00	112.08	22.13	3214.57	145.25
LSD	0.05	4.51	0.58	5.94	0.97	3.64	6.87	2.13	136.13	3.16

*** A.R. = Assimilation rate**

The result presented may be indicat that such tomato cultivar (Castel–Rock) had less genetic and / or physiological and biochemical potential for cold tolerance . Such cold sensitivity to some extend altered by application of different assigned nutrient elements. Regarding, the stimulatory effect of such nutrient elements on vegetative growth characters, it was established that boron (B) plays an indispensable functions in energy, carbohydrates, IAA and phenols metabolism as well as sugar transport and cell wall synthesis (Shelp, 1993 and Bondok, 1996) . Also, zinc (Zn), it was known to evolve an enhancable roles associated with the whole growth activities, particularly during prevailing of the climatic and soil streses . In addition, Zn activates auxin and GA_s synthesis, cell division and enlargement (Alphonse, 1996 and Sekimoto *et al.,*1997) , enhances synthesis and translocation of amino acids and sugars (Cakmak and Marchner, 1988 a and Cakmak *et al.,* 1989). Frurthermore, it displays an antioxidantal and gene regulatory functions against environmental stress conditions (Cakmak and Marschner, 1988 b & c) .Meanwhile, calcium (Ca) has a growth enhancable functions, i.e., activation of cell division an enlargement , synthesis and translocation of bioassimilates which depleted and lacking under stressful conditions (Pereira and Mello, 2002). Also, Ca induces an active and blanced hormonal status of higher IAA and GAs levels vs lower ABA and ethylene

within different plant organs (Ferguson , 1988) Besides, it plays a defensive, protective role against adverse effect of low temperature via its antioxidantal and gene regulatory functions (Clayton *et al.,* 1999 and Sanders *et al.,* 2002).

For phosphorus(P), it is known to be involve in synthesis of ATP the main and unique energy constituent in plant tissues as well as in formation of RNA and phospholipids . Hence, by virtue of that P directly enhances and controls many biosynthesis processes, e.g., carbohydrates and sugars formation, nucleic acids, enzymes and hormones (Yelenosky, 1985) . Such bioconstituents and metabolic changes suggested to be tightly associated with cold acclimation changes and cold tolerance status. Supporting this interpretation could be the suggestion of Tachibana (1987) that P uptake is one of the key processes inhibited by lower soil temperatures.

Therefore, allowing seeds to imbibe the applied B, Zn, Ca and P solutions then spraying seedlings growing up with the same solutions could provide and bring favouring conditions to attain such vigorous growth that was achieved .

II- Photosynthetic pigments in tomato leaves :

Data in Table (2) reveal that during the two assigned seasons, all applied elements at their two used concentrations considerably increased the leaf content of chlorophylls (a & b) and carotenoids. Increases were also in parallel to the applied concentrations of each element. Also, the highest values of chlorophyll a, b and carotenoids were obtained with Zn followed by Ca and P, yet, B showed the lowest increment in this respect.

Table (2): Effect of some nutrient elements on photosynthetic pigments concentration (mg/gm f.wt.) in tomato leaves at 75 day after transplanting during 2004/05 and 2005 / 06 seasons.

Characters		* Chl.						** Carot.		Chl. (a+b) + carot.	
		a		b		a + b					
Treatments (ppm)		$\bar{X}$	± %	$\bar{X}$	± %	$\bar{X}$	± %	$\bar{X}$	± %	$\bar{X}$	± %
		Season 2004 / 05									
Control	0.00	0.87	0.00	0.46	0.00	1.33	0.00	0.54	0.00	1.87	0.00
B	50	1.03	+18.39	0.53	+15.22	1.56	+17.29	0.62	+14.81	2.18	+16.58
	100	1.13	+29.89	0.58	+26.09	1.71	+28.57	0.73	+35.19	2.44	+30.48
Zn	50	1.05	+20.70	0.60	+30.43	1.65	+24.06	0.65	+20.37	2.30	+22.99
	100	1.20	+37.93	0.70	+52.17	1.90	+42.86	0.75	+38.89	2.65	+41.71
Ca	250	0.99	+13.79	0.64	+39.13	1.63	+22.56	0.68	+25.93	2.31	+23.53
	500	1.12	+28.74	0.69	+50.00	1.81	+36.09	0.75	+38.89	2.56	+36.90
P	250	0.99	+13.79	0.57	+23.91	1.56	+17.29	0.61	+12.96	2.17	+16.04
	500	1.13	+29.89	0.66	+43.48	1.79	+34.59	0.74	+37.04	2.53	+35.29
		Season 2005 / 06									
Control	0.00	0.81	0.00	0.43	0.00	1.24	0.00	0.55	0.00	1.79	0.00
B	50	0.96	+18.52	0.50	+16.28	1.46	+17.74	0.61	+10.91	2.07	+15.64
	100	1.10	+35.80	0.57	+32.56	1.67	+34.68	0.68	+23.64	2.35	+31.28
Zn	50	0.96	+19.75	0.56	+30.23	1.53	+23.39	0.62	+12.73	2.15	+20.11
	100	1.16	+43.21	0.67	+55.81	1.83	+47.58	0.74	+34.55	2.57	+43.58
Ca	250	0.95	+17.28	0.62	+44.19	1.57	+26.61	0.64	+16.36	2.21	+23.46
	500	1.06	+30.86	0.67	+55.81	1.73	+39.52	0.73	+32.73	2.46	+37.43
P	250	0.95	+17.28	0.54	+25.58	1.49	+20.16	0.63	+14.55	2.12	+18.44
	500	1.06	+30.86	0.62	+44.19	1.68	+35.48	0.71	+29.09	2.39	+33.52

*** Chl. = Chlorophyll ** Carot . = Carotenoids ± % = ± % relative the control values**

Herein, this stimulatory effect of Zn and Ca on photosyntheic pigments might be due to their action as antioxidants, in which protect chloroplasts against the formation of toxic free radicals, thereby prevent degradation of pigments and inhibit the photooxidation of pigments that arise under stressful conditions (Brown *et al.,* 1993 and Sanders *et al.,* 2002) .

III- Minerals and bioconstituents in tomato leaves :

As shown in Table (3) different applied nutrient elements obviously increased N,P,K, Ca and Mg concentrations in leaves of treated plants compared with those of untreated ones during the two growing seasons . Besides, the concentrations of total sugars, carbohydrates and crude protein were also considerably increased with all applied elements at their used concentrations. Again, increases were in parallel to the applied concentrations of each element. Also, the highest increments were mostly obtained with Zn then Ca followed by P and B, respectively. These results are in harmony with those obtained by El-Desouky and Khedr (2000) using P on squash and Fathy and Khedr (2005) using Zn and Ca on sweet pepper .

Here, it could be concluded that increases of leaf area (Table, 1) and photosynthetic pigments (Table, 2) as well as increment of the dry matter accumulation in leaves indicate the stimulatory effects of those elements upon the efficiency of photosynthesis process, hence more photosynthates being created as well as enhancement of minerals translocation from roots to leaves .

In addition carbohydrates and sugars link to the case of cold tolerance (Frank, 1990) *via* their roles as cellular cryoprotective or osmoregulator agent (Hockaka and Somero, 1973), they protected proteins and enzymes against denaturations induced by cold stress as well as basic substrate for ATP synthesis.

Moreover, phosphorus uptake and level depressed by low temperature (Table, 3 & 6) known to be taken as indicator for energy status, so its level directly associated with cold tolerability or sensitivity.

Furthermore, calcium had a specific role as secondary messenger in signal transduction system and gene expression alteration during stress (Poovaiah and Reddy, 1993) . Besides, Ca and also Mg known to be activated H^+ -ATP– ase membrane pump, the key active machine and site for cations transport and retention , that attributed to alleviation of cold stress adverse effects (Palta , 1990) .

IV- Anatomy of leaflt blade :

As shown in Table (4) and Figs. (1 & 2) all applied nutrient elements with their two assigned concentrations positively affected different studied anatomical features of tomato leaflet blade. Since, thickness of the midrib region was increased over the control value by 6.0 & 30.7%, 6.5&33.6%, 20.8 & 35.7% and 3.5& 10.9% with B at 50 & 100 ppm, Zn at 50 & 100 ppm, Ca at 250 & 500 ppm and P at 250 and 500 ppm, respectively . In addition, length of the main vascular bundle, was also increased with all applied treatments.

Increase reached its highest value (364.5) with Ca at 500 ppm that represent (128.6%) when compared with the control (100%). Also, the width of this bundle was increased with the assigned treatments to reach its maximum with the same treatment (Ca at 500 ppm) Besides, increment the thickness of main vascular bundle was accompanied with an increase in the thickness of its tissue components, i.e., uppermost, and lowermost phloems and xylem tissues. Here, the highest increment was obtained with Ca followed by Zn and B, yet, P showed the lowest increment in this respect.

The stimulating effects of applied nutrient elements on leaflet blade structure may be attributed to their effects on increasing meristematic activity and promotion of vascular cambium tissue which produced higher amount of conducting tissues (El-Shaarawi *et al.*, 2004).

Table (4) : Effect of some nutrient elements on the leaflet blade anatomy of tomato plants during 2005 / 06 season .

Measurements (µ) and counts / Treatments ppm		Thick. of midrib (µ)	Length of main vascular bundle (µ)	Width of main vascular bundle (µ)	Thick. of uppermost phloem tissue (µ)	Thick. of lowermost phloem tissue	Thick. of xylem tissue	No. of xylem vessels/ main bundle	Thick. of lamina	Thick. upper epidermis	Thick. of lower epidermis	Thick. of palisade tissue	Thick. of spongy tissue
*Control	0.00	X 909.1	283.5	490.5	26.1	36.0	221.4	33.5	189.0	19.8	15.3	63.9	90.0
B	50	X 963.6	324.0	554.4	29.7	38.7	255.4	36.8	214.7	21.2	17.1	70.2	106.2
		% 106.0	114.3	113.0	113.8	107.5	115.4	109.9	113.6	107.1	111.8	109.9	118.0
	100	X 1188.5	352.8	511.2	33.8	43.2	276.3	39.3	243.5	21.6	17.1	78.3	126.0
		% 130.7	124.4	104.2	129.5	120.0	124.8	117.3	128.8	109.1	111.8	122.5	140.0
Zn	50	X 468.1	333.9	593.1	29.7	43.2	261.0	37.5	212.9	21.6	17.6	72.9	100.8
		% 106.5	117.8	120.9	113.8	120.0	117.9	111.9	112.6	109.1	115.0	114.1	112.0
	100	X 1214.9	344.7	631.8	36.9	46.8	261.0	42.3	234.9	22.5	18.0	84.6	109.8
		% 133.6	121.6	128.8	141.4	130.0	117.9	126.3	124.3	113.6	117.6	132.4	122.0
Ca	250	X 1098.2	329.4	601.2	33.3	41.4	254.7	35.8	225.6	24.9	18.0	74.7	108.0
		% 120.8	116.2	122.6	127.6	115.0	115.0	106.9	119.4	125.8	17.6	116.9	120.0
	500	X 1233.7	364.5	684.9	37.8	45.0	281.7	38.8	249.3	26.1	20.7	81.0	121.5
		% 135.7	128.6	139.6	144.8	125.0	127.2	115.8	131.9	131.8	35.3	126.8	135.0
P	250	X 936.5	300.3	581.4	28.8	36.0	235.5	35.0	206.6	22.1	18.0	68.4	98.1
		% 103.0	105.9	118.5	110.3	100.0	106.4	104.5	109.3	111.6	17.6	107.0	109.0
	500	X 1008.2	306.9	547.2	30.6	40.5	235.8	35.5	220.5	21.6	17.1	73.8	108.0
		% 110.9	108.3	111.6	117.2	12.5	106.5	106.0	106.7	109.1	111.8	115.5	120.0

*** Control values are considered 100% .**

With regard to lamina thickness as shown in Table (4) and Fig. (2), it was increased with different applied treatments to reach its maximum with Ca at 500 ppm (31.9% of increase) followed by B at 100 ppm (28.8% of increase). Increment of lamina thickness was accompanied by an obvious increase in its comprising tissues, i.e., upper, lower epidermis, palisade and spongy tissues . Also, the highest increase was obtained with Zn at 100 ppm for palisade tissue (32.4% of increase) and B at 100 ppm for spongy tissue (40.0% of increase).

Fig(1): Transverse section through the terminal leaflet midrib region of the 4th apical compound leaf on the main stem of tomato as affected by some nutrient elements (X 60).

a- Control

b- B at 100 ppm **c- Zn at 100 ppm**

d- Ca at 500 ppm **e- P at 500 ppm**

Abb: u.ph. = uppermost phloem tissue, xy. = xylem tissue, l.ph. = lowermost phloem tissue and m.v.b.= main vascular bundle .

Fig(2): Transverse section through the terminal leftlet lamina of the 4th apical compound leaf on the main stem of tomato as affected by some nutrient elements (X 100)

a- Control

b- B at 100 ppm **c- Zn at 100 ppm**

d- Ca at 500 ppm **e- P at 500 ppm**

Abb: u. ep. = upper epidermis, l.ep = lower epidermis, pa. = palisade tissue and sp.= spongy tissue .

In general, the alteration of different traits of leaf anatomy with the all applied treatments is being of great interest.Because these alteration include each of the thickness of photosynthates creator, i.e., lamina tissue and the thickness of their passage (phloem tissue) as well as the thickness of different raw materials passage (absorbed by roots); i.e., xylem tissue thickness as well . It means that these treatments improved translocation and caused more raw materials to be absorbed by roots and reached to leaves as well as more photosynthates to be allocated and partitioned to other plant parts leading to vigorous growth and enhancement of flowering and fruiting of treated plants . In this respect, Atawia and El-Desouky (1997) , Wanas (2002 and 2006) have been confirmed that the improvement of growth and yield in economical plants is mainly due to the increase of cross sectional area of both xylem and phloem tissues .

Therefore, treatments applied in the present study are being of great interest. Since, these treatments could be of economic value not only considering significant increase of obtained yield but also keeping good marketing, diet and taste characteristics as mentioned later .

V- Reproductivity :

As shown in Table (5) all applied nutrient elements, i.e., B and Zn each at 50 & 100 ppm Ca and P at 250 & 500 ppm for each significantly decreased number of days required for starting of flower anthesis of treated plants, hence induced them to flower earlier than untreated ones .

Table (5): Effect of some nutrient elements on flowering, fruit setting and fruit yield of tomato plants during 2004/05 and 2005/06 seasons.

Characters / Treatments (ppm)		Start of flower anthesis (days)	Earliness of flower anthesis (days)	Total No. of flowers / plant	Total No. of fruits/ plant	Fruit setting %	Mean weight (g)/ fruit	Total fruit yield (kg) / plant	Relative total yield (%)	%of dry matter / fruit
		Season 2004 / 05								
Control	0.00	71.11	0.00	65.33	21.78	33.33	58.38	1.27	100.00	4.82
B	50	63.67	7.44	73.89	27.22	36.84	65.03	1.75	137.8	5.38
	100	59.11	12.00	79.78	30.00	37.60	65.67	1.97	155.12	5.91
Zn	50	59.67	11.44	78.11	28.89	36.99	61.61	1.78	140.16	5.70
	100	55.44	15.67	83.67	33.67	40.24	61.48	2.07	162.99	6.17
Ca	250	55.89	15.22	76.44	27.89	36.49	67.05	1.87	147.24	5.53
	500	53.78	17.33	81.22	30.78	37.90	67.90	2.09	164.57	6.07
P	250	64.78	6.33	70.67	25.78	36.48	62.84	1.62	127.56	5.44
	500	60.00	11.11	75.78	28.00	36.94	64.26	1.80	141.73	6.11
LSD	0.05	3.92	-	3.52	1.87	1.72	2.31	0.23	-	0.18
		Season 2005 / 06								
Control	0.00	73.67	0.00	65.67	20.44	33.69	59.69	1.22	100.00	4.74
B	50	66.78	7.89	70.22	25.33	35.07	63.96	1.62	132.79	5.28
	100	62.56	11.11	74.33	27.67	37.22	64.33	1.78	145.90	5.71
Zn	50	64.33	9.34	72.22	25.67	35.54	62.72	1.61	131.97	5.54
	100	56.89	16.78	77.78	29.78	38.29	63.13	1.88	154.10	6.02
Ca	250	60.11	13.56	71.89	26.22	36.47	66.74	1.75	143.44	5.38
	500	58.11	15.56	76.67	28.67	37.39	70.46	2.02	165.57	5.96
P	250	66.44	7.23	68.11	24.44	35.88	63.82	1.56	127.87	5.34
	500	63.56	10.11	72.44	27.22	37.58	63.19	1.78	140.98	5.89
LSD	0.05	4.28	-	2.94	2.22	1.23	2.85	0.16	-	0.25

Earliness was in parallel to the applied concentrations of each element. Also, The highest earliness was existed with 500 ppm of Ca (17.33 days) followed by 100 ppm Zn (15.67 days), yet the lowest earliness (6.33 days) was obtained with P at 250 ppm during the two grown seasons.

With respect to the number of flowers / plant, it was significantly and proportionally increased with the two applied concentrations of each element. The most suprior element in this respect was Zn followed by Ca then B and P, respectively .

As for the percentage of fruit setting , it could be noticed that significant increment with different applied nutrient treatments was abtained during the two grown seasons . The highest percentage of fruit set was obtained with Zn then Ca, and B, while P was the last one in this respect

In addition, data in Table (6) also indicate that total fruits number and yield / plant, the calculated relative total yield and average of fruit weight as well as dry matter percentage / fruit were significantly increased as a result of the applied elements at their assigned concentrations compared with those of untreated plants during both seasons . The most effective treatment that induced the highest increase in total fruit yield/plant was Ca at 500 ppm (2.09 & 2.02 Kg/ plant) followed by Zn at 100 ppm (2.07 & 1.88 Kg/ plant), while the control values were 1.27 and 1.22 Kg/plant during 2004/05 and 2005/06 seasons respectively .

Herein, such improvement in flowering, fruit setting and total fruit yield of tomato by application of different assigned nutrient elements could be expected, since the same treatments exhibited similar effects on number of branches, total leaf area and dry matter accumulation (Table , 1) mineral content (N,P,K, Ca and Mg), carbohydrates and sugars content (Table, 3 & 6) as well as positively altered leaf anatomy (Table, 4 and Fig., 1 & 2) . That means that tomato plants positively affected and altered physiologically and anatomically to cold tolerance case and that, in turn, became able to protect them against the adverse effects of low temperature . So, they grown, flowered and yielded well even under such unconducive conditions .

The present results and interpretation are confirmed by the findings of El-Desouky and Khedr (2000) using P on squash, Fathy and Khedr (2005) using Zn and Ca on sweet pepper and Hyam, (2006) using B on black cumin.

VI- Minerals and bioconstituents concentrations in tomato fruits :

Data in Table (6) show that during both seasons, the two applied concentrations of each assigned element parally increased the mineral concentrations (N,P,K, Ca and Mg), crude protein , total carbohydrates and sugars concentrations as well as vitamin C and total soluble solids (TSS) in the marketable tomato fruits compared with those of the control . The highest increments in this respect were mostly obtained with Zn followed by Ca, P and B, respectively .

Increase of total carbohydrate concentration in tomato fruits could be indicated by improvement the tomato growth regarding efficient photosynthesis and improvement the translocation of their products as well as N,P,K,Ca and Mg to the ultimate fruits as affected by the applied treatments.

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Hence, it could be suggested that these treatments provided conditions led the fruits to be more acceptable for marketing with good quality.

It could be concluded that application of the assigned nutrient elements, i.e., B, Zn (at 50 & 100 ppm for each), Ca and P (at 250 & 500 ppm for each)as soaking materials for tomato seeds then as foliar spraying on their seedlings, exhibited vigorous tomato growth, caused earliness of flowering and fruit production and increased their capacity. All of these could be attributed to the increment of photosynthesis efficiency and, in turn, the sufficient assimilates supply. Hence, higher fruit yield with good quality to be achieved. Therefore, all of these advantages make the applied nutrient elements to be recommended as effective and safe agricultural practice in cultivation of such summer tomato cultivar outdoors even during winter season to avoid all cautions about inserting the green- houses in agricultural system .

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محاولات لتحسين نمو وإنتاجية نباتات الطماطم النامية فى الموسم الشتوى

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تـأثر نمـو نباتـات الطمـاطم صـنف كاسـل روك والمنزرعـة فـى الشـتاء تحـت ظـروف الحقـل المكشوف خـلال موسمى ٢٠٠٤/٢٠٠٥ ، ٢٠٠٥/٢٠٠٦ تـأثراً إيجابياً نتيجـة المعاملـة بعناصـر البـورون والزنك بتركيزى ٥٠ ، ١٠٠ جزء فـى المليون لكل منهـا والكالسيوم والفوسفور بتركيزى ٢٥٠ و ٥٠٠ جزء فى المليون . حيث حدثت زيادة معنويـة فـى كل من طـول السـاق ـ عـدد الأفـرع والأوراق / نبـات ـ مساحة الأوراق الكلية ـ والأوزان الطازجة والجافة لكل من السوق والأوراق فى حين حدث نقص معنوى فى معدل التمثيل مع كل معاملات العناصر المستخدمة .

بجانـب ذلـك فقد أدى التركيـزين المسـتخدمين مـن كـل عنصـر إلـى زيـادة تناسـبية فـى مسـتوى صـبغات التمثيـل الضـوئى ـ العناصـر المعدنيـة (النيتـروجين ، الفوسـفور ، البوتاسـيوم ، الكالسـيوم والماغنسيوم) ـ السكريات ـ الكربوهيدرات الكليـة وكذلك البـروتين فـى أوراق النباتـات المعاملـة مقارنـة بمثيلا تها فى النباتات غير المعاملة .

بالإضافة إلى ذلك فإن النمو القوى المتحصل عليه لنباتات الطماطم نتيجـة لتاثرها بالمعـاملات المستخدمة كـان مصـحوباً بتغير واضـح فـى العديـد من الصـفات التشريحية للأوراق حيـث سببت جميـع المعاملات زيادة فى سمك النصـل ومكوناتـه النسيجية وهـى البشرتين العليـا والسفلى والنسيجين العمـادى والأسفنجى كما سببت أيضاً زيادة فى سمك العرق الوسطى وأبعاد الحزمة الوعائيـة وسمك أنسـجة اللحـاء والخشب .

وعلاوة على ذلك فقد سببت جميع معاملات العناصر المستخدمة تبكير فى الإزهار وزيـادة فـى عدد الأزهار والنسبة المئوية لعقد الثمار وزيادة عدد ووزن الثمـار / نبـات . وقد ظهـرت أعلـى زيـادة فـى المحصول الكلى مع النباتات المعاملة بالكالسيوم بتركيز ٥٠٠ جزء من المليون يليها تلك المعاملـة بالزنـك بتركيز ١٠٠ جزء فى المليون ثم المعاملة بالبورون بتركيز ١٠٠ جزء فى المليون ثم المعاملـة بالفوسـفور بتركيز ٥٠٠ جزء فى المليون . وفى نفس الوقت سببت جميـع المعـاملات المستخدمة زيـادة فـى محتـوى الثمار من العناصر المعدنية والسكريات والكربوهيدرات وكذلك فيتامين ج والجوامد الصلبة الكلية

وبناء على ذلك فإن الدراسة الحالية توصى بقوة باستخدام مثل هذه العناصـر المغذيـة ليس فقط من أجل تحسين النمو بل وأيضـاً من اجل تبكير وزيـادة محصـول الثمـار لنباتـات الطمـاطم خصوصـاً فـى الموسم الشتوى تجنباً لإستخدام الصوب الزجاجية فـى الزراعـة . كمـا أن هذه العناصـر لهـا دور كبير فـى مقاومة الإجهاد بالبرودة والتى تتعرض له نباتات الطماطم فى هذه الفترة الزمنية التى تنخفض فيها درجـة الحرارة بصورة واضحة.

Table (6): Effect of some nutrient elements on minerals and bioconstitunt concentrations of tomato fruits during 2004 / 05 and 2005/06 seasons .

Determinations / Treatments (ppm)		Mg / g d. f.wt.											Mg / g f. wt.				Vitamin C mg / 100g F.W.		TSS (%)
		N	P	K	Ca	Mg	Total determined elements		Crude protein		Total carbrohydr-ates		Reducing sugars	Non-reducing sugars	Total sugats				
							$\bar{X}$	± %	$\bar{X}$	± %	$\bar{X}$	±%			$\bar{X}$	± %	$\bar{X}$	± %	
		Season 2004 / 05																	
Control	0.00	22.32	3.12	23.86	16.94	3.27	69.51	0.00	139.50	0.00	556.36	0.00	9.56	4.43	13.99	0.00	21.20	0.00	4.82
B	50	23.76	3.48	24.88	17.64	3.86	73.62	+5.91	148.50	+6.45	584.94	+5.14	11.65	5.38	17.03	+21.73	23.62	+11.42	5.44
	100	25.34	3.81	26.84	20.57	4.58	81.14	+16.73	158.38	+13.53	592.68	+6.53	14.52	6.65	21.17	+51.32	24.33	+14.76	6.11
Zn	50	24.88	3.34	25.96	19.78	4.28	78.24	+12.56	155.50	+11.47	597.26	+7.35	14.18	6.36	20.54	+46.82	25.05	+18.16	5.70
	100	27.95	3.62	28.75	23.90	5.12	89.34	+28.53	174.69	+25.23	624.85	+12.31	14.96	6.96	21.92	+56.68	26.32	+24.15	6.17
Ca	250	24.18	3.43	25.47	21.85	4.46	79.39	+14.21	151.13	+8.34	585.67	+5.27	12.16	5.94	18.10	+29.38	24.56	+15.85	5.53
	500	26.83	3.62	28.26	25.66	5.32	89.69	+29.03	167.69	+20.21	609.45	+9.54	14.84	7.06	21.90	+56.54	25.67	+21.08	6.07
P	250	23.94	3.52	24.68	19.12	3.82	75.80	+8.01	149.63	+7.26	578.52	+3.98	11.98	5.72	17.70	+26.52	23.42	+10.47	5.38
	500	26.12	3.83	26.44	22.96	4.64	83.99	+20.83	163.25	+17.03	603.37	+8.45	14.75	6.80	21.55	+54.04	24.26	+14.43	5.82
		Season 2005 / 06																	
Control	0.00	21.68	2.92	23.42	16.00	3.15	67.17	0.00	135.50	0.00	531.44	0.00	9.17	4.28	13.45	0.00	20.71	0.00	4.74
B	50	22.83	3.23	24.31	17.31	3.82	71.50	+6.44	142.69	+5.31	569.69	+7.20	11.08	5.16	16.24	+20.74	23.08	+11.44	5.34
	100	25.62	3.68	26.96	19.62	4.42	8.03	+19.55	160.13	+18.18	578.28	+8.81	13.63	6.47	20.10	+49.44	23.47	+13.33	5.89
Zn	50	24.02	3.16	25.15	20.02	3.96	76.31	+13.61	150.13	+10.80	577.82	+8.73	13.38	6.25	19.63	+45.95	24.37	+17.67	5.54
	100	26.23	3.37	27.78	23.24	4.78	85.40	+27.14	163.94	+20.99	6.9.45	+14.68	14.65	6.82	21.47	+59.63	25.64	+23.80	6.02
Ca	250	23.07	3.18	24.88	20.78	4.14	76.05	+13.22	144.19	+6.41	568.14	+6.91	11.98	5.73	17.71	+31.67	24.16	+16.66	5.38
	500	26.02	3.44	27.18	24.48	4.84	85.96	+27.98	162.63	+20.02	599.95	+12.89	14.12	6.94	21.06	+56.58	24.85	+19.99	5.96
P	250	22.96	3.25	24.52	19.24	3.73	73.70	+9.72	143.50	+5.90	574.87	+8.17	11.78	5.46	17.24	+28.18	22.69	+9.56	5.26
	500	25.92	3.76	26.48	21.73	4.66	82.55	+22.90	162.00	+19.56	597.16	+12.37	14.04	6.68	20.72	+54.05	23.82	+15.02	5.61

Table (3): Effect of some nutrient elements on minerals and bioconstitunt concentrations in tomato leaves at 75 days after transplanting during 2004/05 and 2005/06 seasons.

Determinations / Treatments (ppm)		Mg / g d. wt.											Mg / g f. wt.			
		N	P	K	Ca	Mg	Total determined elements		Crude protein		Total *carb.		Reducing sugars	Non-reducing sugars	Total sugars	
							$\overline{X}$	± %	$\overline{X}$	± %	$\overline{X}$	±%			$\overline{X}$	± %
		Season 2004 / 05														
Control	0.00	29.54	3.43	31.22	24.62	4.52	93.33	0.00	184.63	0.00	376.28	0.00	5.79	2.49	8.38	0.00
B	50	31.94	3.73	34.76	27.28	4.88	102.59	+9.92	199.63	+8.12	394.52	+4.85	7.29	2.99	10.28	+22.67
	100	36.88	4.18	36.84	29.96	5.28	113.14	+21.23	230.50	+24.84	412.50	+9.63	9.02	3.78	12.80	+52.74
Zn	50	32.63	3.75	36.96	28.86	5.30	107.50	+15.18	203.44	+10.22	406.48	+8.03	8.78	4.16	12.44	+54.44
	100	38.52	4.21	38.14	33.18	6.44	120.49	+29.10	240.75	+30.40	426.37	+13.31	10.18	4.32	14.50	+73.03
Ca	250	33.76	3.83	34.68	31.32	5.54	109.13	+16.93	211.00	+14.28	401.86	+6.80	9.02	3.88	12.90	+53.94
	500	37.74	4.24	36.82	34.76	6.80	120.36	+28.96	235.88	+27.76	418.22	+11.15	9.98	4.14	14.12	+68.26
P	250	33.42	3.90	32.78	28.64	4.96	103.70	+11.11	208.88	+13.13	396.18	+5.29	8.62	3.76	12.38	+47.73
	500	37.82	4.46	35.66	31.56	5.62	115.12	+23.35	236.38	+28.03	415.74	+10.49	9.86	4.10	13.96	+66.59
		Season 2005 / 06														
Control	0.00	27.92	3.55	29.68	22.72	4.40	88.27	0.00	174.50	0.00	348.50	0.00	5.67	2.33	8.00	0.00
B	50	29.84	3.68	33.08	25.84	4.76	97.20	+10.12	186.50	+6.88	374.43	+7.44	7.42	2.92	10.34	+29.25
	100	35.16	4.07	35.64	27.68	5.08	107.63	+21.93	219.75	+25.93	386.16	+10.81	9.18	3.64	12.82	+60.25
Zn	50	31.94	3.78	33.92	26.92	5.12	101.68	+15.19	199.63	+14.40	385.24	+10.54	8.36	3.74	12.10	+51.25
	100	36.62	4.12	36.28	30.86	6.16	114.04	+29.19	228.88	+31.16	400.75	+14.99	9.98	4.02	14.00	+75.00
Ca	250	30.74	3.76	31.56	30.12	5.14	101.32	+14.78	192.13	+10.10	380.92	+9.30	8.88	3.56	12.44	+55.50
	500	35.12	4.16	34.94	32.44	6.48	113.14	+28.17	219.50	+25.79	398.44	+14.33	9.62	3.83	13.45	+68.13
P	250	32.16	3.96	31.98	26.12	4.80	99.02	+12.18	201.00	+15.19	378.92	+8.73	8.12	3.32	11.44.	+43.00
	500	35.08	4.30	33.82	29.28	5.28	107.76	+22.08	219.25	+25.64	392.38	+12.59	9.52	3.85	13.37	+67.13

*** Carb. = Carbohydrates** **± % = ± relative to the control values**