J. Agric. Sci. Mansoura Univ., 25 (6): 3569 - 3586, 2000.

SCREENING FOR COLD TOLERANCE IN TOMATOES USING SOME PROMISING PHYSIOLOGICAL AND METABOLICAL BASIS.

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ABSTRACT

Experiments were conducted during early summer seasons of 1996/97 and 1997/98 to screening for sold tolerance among different tomato genotypes, i.e. (MHX 668, MHX 4953, MHX 975, US, LX II, GR and Super Marmand) depending on some physiological and metabolical basis. The results could be summarized as follow:-

All the studied genotypes were significantly varied in their morphological, physiological and metabolical behaviour under low temperature condition in open field.

Genotypes arranged from the best to the worst in their dry matter, chlorophyll, total protein, soluble sugars and minerals as well as pollen grain weight and germination %, fruit setting and yield) and in reverse order dealing with I_1 and I_2 index of cold responses (tolerance or sensitive) as follows: MHX 668 - Lx 4 - MHX 4953 - US - Super marmand.

- GR and at least MHX 975, respectively.

Fruit setting % and yield were significantly and positively correlated with all the studied parameters and negatively with I_1 and I_2 index.

It was found that MHX 668 and LX II were significantly the best genotypes in growth, fruit setting and yield under stress condition due to their superior physiological and metabolical behaviour and function during their different stages of development. Herein it could be concluded that, those must be utilized in breeding programs for producing new cold tolerant tomato cvs or to be directly cultivated in early summer seasons.

The possibility of using one or more physiological or metabolical parameters in one or more development stage as a rapid and accurate technique for cold tolerance screening, i.e. I_1 (Ch_0/Ch_1) index, I_2 (EC_1/EC_2) index (their lower values indicated an cold tolerance case, whereas higher ones indicated cold injury case). Also, soluble sugars, total protein, minerals (N, P, K and Ca) as well as pollen grain weight and germination percentage, all in higher values associated with cold tolerance.

INTRODUCTION

Tomato cultivation for early summer harvesting specially in north Egypt is always limited due to unfavourably low temperatures prevailing in December, January, February and early of March every year.

Most of the cultivated tomato cultivars are chilling (temperatures below 12°C > 0°C) sensitive plants (Lyons, 1973; Scott and Jones, 1982; Handley *et al*., 1986; Hassan and Marghany, 1987; Soliman, 1988; Saltivat and Morris, 1990; Soliman, 1992 a & b). Their growth, flowering, fruiting and yield are strongly depressed under such stress condition. Due to the incidence of many physiological and biochemical related disorders as reduction and/or damaged of photosynthesis, and respiration rate or sites (Maciejewska *et al*., 1984; Smeets and Hagenboom, 1985(, restriction and alteration in RNA and protein

metabolism (Levitt, 1980), depression in ATP and NADPH synthesis (low energy case) also in carbohydrate reserves, phosphorus content and accumulation of toxic NH_4 (Sinclar, 1967; Sobozyk *et al*., 1985 and Rabe and Lovatt, 1986), disturbances in membranes structure and function (H^+-ATP-ase membrane pump inactivation and electrolyte leakage) (Steponkus, 1984; Iswari and Palta, 1989; Palta, 1990, Rabe and Saltveit, 1996) and chlorophyll degradation (Kamps *et al*., 1987 and Walker *et al*., 1990).

Efforts to overcome the adverse effects of chilling stress on outdoor tomatoes, have been practiced in the past using different methods either by modify the environment or the plants themselves. So, screening and selection of plants which have superior traits related to cold tolerance is highly needed. This should be form the fundamental base to produce cold tolerance varieties via classic breeding and/or genetic engineering. Up till now, there are no stable basis or techniques to assess for cold sensitivity or tolerability. Except those which paid great attention to the morphological, and reproductive verifications and abnormalities among different tomato genotypes under open field and cold stress conditions. Morphological verifications were described by Morris (1982), King and Reid (1986), Patterson (1988), Abou-Hadid *et al*. (1987), Singer *et al*. (1988), Soliman (1988 and 1992a)..

Cold related abnormalities and varibility in flowering and fruiting of tomatoes were estimated and detected by Kemp (1968), Minges (1972), Nandpuri *et al*. (1975), Sawhney and Polowick (1985), Rylski (1986), Hassan and Marghany (1987) and Soliman (1992b). Verifications in yield were obtained by Nandpuri *et al* (1975), Nassar (1986), Radwan *et al.* (1986), Hassan and Marghany (1987), Soliman (1988) and (1992b). In parallel with these, it was pointed out that cold tolerance is genetically varied (Gay and Eagles, 1991), and it is a quantitative trait transferred from the parents to the progeny (Auld *et al.*, 1983 and Norell *et al.*, 1986).

Less attention had been paid to the physiological and biochemical status and traits (normal or disturbed) as an promising, accurate and rapid basis for cold tolerance evaluation. Those which known to be tightly related with the case of gene activities (expression) via the known pathway of DNA $\rightarrow$ mRNA $\rightarrow$ protein / enzyme $\rightarrow$metabolic process $\rightarrow$ transcriptional bioconstituents. As, sugars, amino acids, hormones, minerals, chlorophyll content and etc. of known association with low temperatures responses (so called molecular genetic), and its involvement in cold stress tolerance (Weiser, 1970 and Robertson *et al*., 1987).

Therefore, the work must be conducted and great attention should be paid to more promising physiological and biochemical techniques / basis for cold tolerance screening. Such promising basis as:

Chlorophyll florescence or chlorophyll index (chlorophyll metabolism during cold stress) (Kamps *et al*., 1987; Walker and Smith, 1990).

The electrolyte leakage index (EC_1/EC_2), a technique for measuring the degree of chilling injury and cold responses (Singer *et al*., 1989 and Singer *et al*., 1993).

The bioconstituents, i.e., carbohydrates, sugars, protein, amino acids as internal osmoregulators, cryoprotective agents and energy materials (Weiser, 1970; Rikin *et al*., 1976; Kacperska-Palacz, 1978; Levitt, 1980;

Morgan, 1984; Smeets and Hogenboom, 1985; Vande Dijk and Maris, 1985; Robertson *et al*., 1987, Cooper and Ort, 1988, Guy and Haskell, 1989 and Li, 1993).

The mineral content, i.e., P, K and Ca as indicator for ATP status and the activity of H^+-ATP-ase system (Iswari and Palta, 1989, Palta, 1990; Poovaiah and Reddy, 1993).

Pollen grain and flower weight (Minges, 1972; Nandpuri, 1975; Maisonneuve and Philouze, 1982).

Germination percentage of pollen grain during low temperature stress (Gentile and Santer, 1971).

The present work aimed to be estimate and screen of some tomato genotypes using some promising (stable, rapid and accurate) physiological and metabolical parameters. This at least as fundamental base to produce cold tolerant tomato varieties via the known breeding programs.

MATERIALS AND METHODS

Field experiments were conducted at Mansoura Research Station in early summer seasons of 1996/97 and 1997/98 to study and focus on the physiological, nutritional and metabolical behaviour of some tomato genotypes under low temperature condition.

Seeds of MHX 668, MHX 4953, MHX 975, LX II, US, GR and Super Marmand genotypes were received from Hort. Res. Institute, Giza to be estimated during cold seasons in north Egypt.

Seeds were sown in foam trays filled with vermiculite and peat (1:1) mixed with the recommended amendments. Trays were kept in white flay protected greenhouse. Seedlings (35 day) age were transplanted (on November 10th in both seasons) in one side ridge (5 ridges / plot) of 5 m length, 1.2 width and 35 cm apart. All cultural practices were performed as recommended.

A randomized complete block design of seven tomato genotypes with four replicates was adopted.

Experimental procedure:

1. Morphological parameters (growth):

At the middle of harvesting season, five plants from each plot were removed for measuring plant height (cm), number of leaves and shoots per plant, fresh and dry weight (gm) per plant.

2. Chlorophyll content and I_1 (CH_0 / Ch_1) index:

Samples of fresh leaves (from each tomato genotype plants) were used for determination of chlorophyll a, b and total according to the method of Wintermans and DeMots (1965). The values were calculated on fresh weight basis and expressed as mg/100 gm fresh weight. Same samples were subjected to artificial cold stress (2°C for 48 hr.). Once again chlorophyll's determined after exposure to stress.

I_1 (Ch_0 / Ch_1) index was calculated based on the method of Nomai (1982), and Walker and Smith (1990).

Where:

Ch_0 : total chlorophyll before exposure to cold stress.

Ch_1 : total chlorophyll after exposure to cold stress.

I_1 index: ratio of Ch_0 / ch_1 used as indicator for cold responses. Higher I_1 value related to cold sensitivity, whereas, lower value related to cold tolerance and the best value is $I_1 < 1$ (Walker and Smith, 1990).

3. I_2 (EC_1 / EC_2) index (electrolyte leakage or injury index):

Leaf discs 3.5 cm diameter were taken from the first fully expanded leaf of each genotype (20 discs) then these were subjected to 2°C for 48 hr. Discs were replaced into tubes containing 10 ml distilled water and put under vacuum. The tubes were shaken for 1 hr. and centrifuged for 10 min. hence the first conductance (EC_1) was measured using electrode (digital cond./temp.) meter. Thereafter, the tubes were freezed for 24 hr. and subjected to the same procedure then, a second conductance (EC_2) was measured. I_2 index was the ratio of EC_1 / EC_2, It was use as indicator for electrolyte leakage and cold injury. Value below (0.5) indicated an cold tolerance response, whereas this above (0.5) indicated cold sensitive and injury case. Such method and procedure was modified after Singer *et al*. (1989) and Singer *et al*. (1993).

4. Minerals and bioconstituents:

At full blooming stage sample of fresh leaves and shoots were taken for analysis of minerals, N, P and K were determined according to the methods of Cotton (1954), whereas Ca analyzed by atomic absorption method. Soluble sugar was determined at dry matter basis according to Nelson (1944) and expressed as soluble sugar percentage, total protein calculated as mg / gm dry weight based on nitrogen content.

5. Pollen grain weight and germination (%):

a. Pollen grain weight:

Anthers of five flowers from the first truss were collected just at anthesis (from the plants of each genotype) then, the weight was recorded (gm/5 flowers). Also, twenty flowers were weighted and the average weight of the flower (gm) was registered. Those were used as physiological indicator for cold sensitivity or tolerability under stress condition (Maisonneuve and Philouze, 1982).

b. Pollen grain germination (%):

Just at anthesis of the first clusters flowers of different genotypes, anthers were collected and kept in refrigerator (5°C for five days). Then, these chilled pollen grains allowed to be germinated in artificial liquid medium (5% sucrose and 100 ppm boric acid). The chilled pollen grains were taken by needle and put on slides with drop of liquid medium and covered with glass covers. Slides were kept in plastic pages with watered filter papers in

refrigerator over night. The number of germinated grains was counted under microscope in two separated fields, also, the total number was recorded.

$$\text{Germination \%} = \frac{\text{No. of germinated grains*}}{\text{Total No. of grains}} \times 100$$

* their tubes were emerged.

This procedure was according to the method of Gentile and Santer (1971).

6. Fruit setting percentage and fruit yield:

Fruit setting % calculated during the whole season from this formula:-

$$\frac{\text{No. of fruits / plant} \times 100}{\text{No. of flowers / plant}}$$

Yield (Kg/plant) was calculated from the weight of all harvested fruits / plot divided by the number of plants / plot.

Also, air temperatures during the two seasons of this work is presented in Table (1).

Table 1. Mean monthly air temperature in El-Mansoura during 1996/97 and 1997/98 seasons.

Months	Temperature (°C)					
	Max.	Min.	Mean	Max.	Min.	Mean
	1996/97 season			1997/98 season		
September	32.2	18.9	25.6	--	--	--
October	29.7	14.4	21.9	--	--	--
November	24.5	10.8	17.8	22.5	11.9	17.4
December	21.5	8.5	15.0	15.4	7.5	11.4
January	18.0	6.6	12.3	18.2	8.4	13.3
February	18.0	6.5	12.3	19.7	9.2	14.4
March April	18.5	8.5	13.5	20.4	9.2	14.8
	22.3	12.3	20.0	25.9	12.6	19.2

All the obtained data were subjected to computer analysis and correlations among some parameters were doing.

RESULTS AND DISCUSSION

Under present work condition, data in Table (1) indicated that different tomato genotypes (which transplanted on 10th November of 1996/97 and 1997/98 seasons) were actually under cold stress condition during their critical stages of growth, flowering and setting. Since the tabulated temperatures (night ones) during this period (from the beginning of November up to end of March) were below 12°C) and above O°C during both seasons. Similar findings about the temperature range for cold-sensitivity in tomatoes

were obtained by Lyons (1973), Scott and Jones (1982), Handley *et al*. (1986), Hassan and Marghany (1987), Soliman (1988), Saltivat and Morris (1990), Soliman (1988) and (1992b).

Meanwhile, such stress condition during the two seasons represent an true natural case to screen for cold tolerance among the studied tomatoes using different basis and techniques, i.e., dry matter accumulation, chlorophyll and electrolytes case, minerals, protein and soluble sugars status as well as some pollen grain parameters.

1. Growth and dry matter accumulation:

Data in Table (2) indicated that, most of the studied tomato genotypes, i.e., GR, Super Marmand, MHX 668, MHX 975, MHX 4953, US and LX II were significantly differed in their growth behaviour, plant height, number of leaves and shoots, fresh and dry weight, all per plant) during the two seasons of 1996/97 and 1997/98.

The same data cleared that MHX 668 followed by LX II and MHX 4953 were the most superior genotypes relative to the others with considerable differences among them in most cases. It was evident also that US and Super Marmand were of intermediate growth behaviour relative to the above superior genotypes and to those of the lowest growth parameters, i.e., GR and MHX 975. Less differences were detected among US and Super Marmand and among GR and MHX 975 in both seasons.

Similar results about growth varifications among tomato cvs and genotypes under natural cold stress in open field were obtained by Kacperska-Palacz (1978), Morris (1982), King and Ried (1986), Patterson (1988), Abou-Hadid *et al*. (1987), Singer *et al*. (1988), Soliman (1988) and (1992a).

Under present work condition, the growth and dry matter accumulation behaviour of different tomato genotypes as they arranged in decreased order, MHX 668, LX II, MHX 4953, US, Super Marmand, GR and at least MHX 975 could be logically true. Since, they were behaved in similar fashion dealing with minerals and bio-constituents content, i.e., N, P, K, Ca, chlorophyll a, b and total before and after exposure to cold stress (2°C for 48 hr.), protein and soluble sugars (Table 3 and 4).

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On the other hand, they behaved in reverse fashion dealing with the I_1 (Ch_0/Ch_1) index (chlorophyll degradation and cold responses indicator) and EC_1 / EC_2 (I_2 index) (electrolyte leakage and cold responses another indicator). (Table, 3). It was known that Ch_0 / Ch_1 and EC_1 / EC_2 higher values could be closely related to cold sensitive case, whereas lower values associated with cold tolerance case.

Meanwhile, these genotypes reflected their morphological characters and dry matter yield under stress condition on their fruit setting and yield in similar fashion (the same order) with significant positive correlation (Table 5 and 6).

Accordingly and based on the detected strong correlation between dry matter yield (as growth and physiological indicator) and fruit yield as a final gain for all plant activities, functions and responses during cold stress. It could be suggested that the potentiality of these genotypes for tolerating cold stress during growth stage should be in the same prior order.

2. Chlorophyll content, I_1 and I_2 index:

Data in Table (3) revealed that most tomato genotypes were significantly differed in all the studied chemical parameters, i.e., chlorophyll a, b, total (before and after exposure to cold stress), I_1 index (Ch_0 / Ch_1) and I_2 index (EC_1 / EC_2) at both seasons. Same data cleared that these genotypes could be arranged from the highest to the lowest values of chlorophyll a, b and total before and after exposure to cold stress (2°C for 48 hr.) and reversely for I_1 and I_2 values as follows: MHX 668, LX II, MHX 4953, US, Super Marmand, GR and at least MHX 975.

Under present work condition, it was found that these genotypes were extended their present biochemical behaviour in similar fashion to their growth, fruiting and yield (Tables 2 and 5). Also, I_1 and I_2 index values were significantly and negatively correlated with fruit setting and yield of these genotypes in the two seasons (Table 6).

On the other hand, it was known that cold sensitivity case associated with disturbances in cell membrane structure and function (restriction in membrane pumping system / H^+-ATP-ase pump), this lead to disturbance in cell ionic, osmotic, and conductivity status, thereby the electrolyte leakage (Steponkus, 1984; Iswari and Palta, 1989; Palta, 1990 and Rabe and Saltveit, 1996).

Also, chlorophyll formation or degradation process during low temperature stress known to be related with cold tolerability responses (Kamps *et al*., 1987 and Walker *et al*., 1990).

Additionally, I_1 (Ch_0 / Ch_1) value, the index for chlorophyll stability or degradability state during cold stress had been taken as rapid indicator for cold responses (the higher I_1 value related to cold sensitivity and the reverse is true (Kamps *et al*., 1987 and Walker and Smith, 1990). Also, I_2 (EC_1 / EC_2) values, the index for electrolyte leakage known to be a rapid and accurate indicator for cold responses (the higher I_2 value above 0.5 or 50% is related to cold sensitivity and the value down 0.5 links to cold tolerance case (Singer *et al*., 1989 and Singer *et al*., 1993).

Accordingly, it could be classified MHX 668 and LX II genotypes as the most cold tolerable ones. Those of the best chlorophyll stability and ionic case (lowest electrolyte leakage) during stress. As regards, the ions content (K and Ca) (Table 4) coincided this view since, the lower I_2 values paralleled the higher K and Ca content and the reverse was true. At the same basis, MHX 975 and GR classified as the most cold-sensitive genotypes, and the others were as intermediate ones.

3. Minerals and bioconstituents:

Data in Table (4) indicated that different genotypes were significantly varied in their mineral content (N, P, K and Ca) and their bioconstituents (total protein and soluble sugars at both seasons).

The same data cleared that MHX 668 was significantly of the highest minerals, proteins and soluble sugars followed by LX II with significant differences among them in all contents except Ca content in the two seasons.

MHX 4953, US and Super Marmand were followed the above genotypes in decreased order respectively with noticeable differences among them in some cases. Also, it was evident that Super Marmand was superior in its nitrogen and protein content relative to all genotypes, but not to MHX 668. At least, MHX 975 and GR were significantly of the lowest minerals and bioconstituents relative to other ones with less differences among them in most cases.

Similar results were obtained by Iswari and Palta (1989), Palta (1990), Poovaiah and Reddy (1993) about mineral content and function during cold stress (Weiser, 1970; Rikin *et al*., 1976; Kacperska-Palacz, 1978; Levitt, 1980; Morgan, 1984; Smeet and Hogenboom, 1985; Van de Dijk and Maris, 1985; Robertson *et al*., 1987; Cooper and Ort, 1988; Guy and Haskell, 1989 and Li, 1993) all about verifications in minerals and bioconstituents.

As regards and based on the nutritional and metabolical order and status of these genotypes, it could be suggested that they responded to cold stress (tolerance or sensitive) in the same order. Since, they affected fruit setting and yield in similar fashion and in significant positive correlation (Tables 5 and 6). Beside this, they affected dry matter accumulation, chlorophyll content in the same trend (Tables 2 and 3).

It is great advantageous to obscure and gave insight on the function of these organic and non-organic components in association with cold tolerance. It was known that the cold sensitive genotypes under cold stress condition exhibited an strong disturbances in their energy metabolism (low energy case), poor nutritional condition (low phosphorous and calcium content), low sugar and protein content, protein denaturation and disorder in ionic and osmotic state (Sinclar, 1967; Levitt, 1980; Maciejewska *et al*., 1984; Smeets and Hagenboom, 1985; Sobozyk *et al*., 1985 and Rabe and Lovatt, 1986). In contrary, cold-tolerable genotypes known to be own reverse case. The higher phosphorus and soluble sugars of MHX 668 and LX II under stress condition might be a function and indicator for normal energy metabolism (ATP generation), since the sugars utilized as basic substrate in

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respiration, P (pyrophosphate) as a main component of ATP synthesis. Also, sugars, proteins and ions had a key role in osmoregulation and water relations added to the role of sugars as cryoprotective agent during cold stress. On the other hand, Ca implicated in cold tolerance induction via its role as a messenger for alteration of gene expression, also via its role in activation of membrane pump system (H^+-ATP-ase) (Iswari and Palta, 1989; Palta, 1990 and Poovaiah and Reddy, 1993).

So, it could be emphasize on the conducive internal nutritional and metabolical status in relation with cold tolerance. Also, it might be suggested that cold tolerance responses primarily start at the gene level (alteration in gene expression / activity) and undergo toward the synthesis of the cold tolerance-related metabolites (DNA-mRNA $\rightarrow$ protein / enzyme $\rightarrow$ bio-constituents) (Weiser, 1970; Auld *et al*., 1983; Norell *et al*., 1986; Robertson *et al*., 1987 and Gay and Eagles, 1991).

4. Fruit yield and some parameters during flowering and fruiting stages:

Data in Table (5) gave insight on other important basis as the flower average weight (gm), pollen grain weight (gm) (of five flowers), germination percentage of pollen grain and the percentage of fruit setting besides fruit yield (kg) per plant as a final gain for the actions and functions of the present traits and of all previously presented traits (Tables 2, 3 and 4) all at both seasons.

The same data indicated that a considerable differences were detected among the studied tomato genotypes in most cases in the two seasons.

In this connection, such genotypes exhibited similar behaviour as they previously did and arranged (MHX 668, LX II, MHX 4953, Super Marmand, US, GR and at least MHX 975), respectively in descending order. Also, the yield of those followed the same order. Otherwise, the genotype of higher fruit yield was the same of higher pollen grain weight and germination percentage, higher flower average weight and fruit set percentage and *vice versa*.

Additionally, it was found that such specific traits were significantly and positively correlated with fruit setting percentage and yield (Table, 6), and all were in full harmony with all the previously studied traits as affected by the same genotypes (Tables, 2, 3 and 4).

This might be confirmed by the findings of Gay and Eagles (1991) about the genetically controlling and variation of cold tolerance, Auld *et al*. (1983) and Norell *et al*. (1986) about the hertability of this trait.

Similar results about the verifications in flowering and fruiting of tomatoes were of Kemp (1968), Minges (1972), Nandpurie *et al*. (1975), Sawhney and Polowick (1985), Rylski (1986), Hassan and Marghany (1987) and Soliman (1992b); for yield were of Radwan *et* al. (1975), Nassar (1986), Marghany (1987), Soliman (1988) and (1992b). As well as Minges (1972), Nandpuri (1975) and Maisonneuve and Philouze (1982) for using of pollen grain weight as indicator for cold tolerance, Gentile and Santer (1971) for the similar use of pollen grain germination percentage.

Finally, it could be suggested that in screening for cold tolerance of tomato genotypes to be utilized in the programs of breeding and improvement. I_1 (Ch_0 / Ch_1), I_2 (EC_1 / EC_2), minerals (N, P, K and Ca),

proteins and soluble sugars as well as flower average weight, pollen grain weight and germination percentage could be successfully used for this propose. Also, it could be concluded that NHX 668 and LX II were the most promising cold tolerable tomato genotypes under the present work condition.

5. Correlation studies:

The data in Table (6) showed that total dry weight, average weight of flower and germination percentage of pollen grain were in highly significant positive correlation with fruit set percentage and fruit yield, whereas pollen grain weight was correlated only with fruit set percentage, all at both seasons.

Table (6). Correlation (r) values of fruit setting (%) and yield vrs. some physiological and metabolical parameters of the different tomato genotypes during 1996/97 and 1997/98.

Parameters *vrs.*	1996/97		1997/98	
	Fruit setting (%)	Yield (Kg) plant	Fruit setting (%)	Yield (Kg) plant
Dry weight (gm) /plant	0.930**	0.919**	0.927**	0.858*
Average wt. of flower (gm)	0.943**	0.907**	0.943**	0.908**
Pollen grain wt / 5 flowers (gm)	0.793*	0.700	0.788*	0.707
Pollen grain germination (%)	0.942**	0.934**	0.931**	0.899**
I_1 (Ch_0/Ch_1) index	-0.898**	-0.877**	-0.936**	-0.927**
I_2 (EC_1/EC_2) index	-0.877*	-0.919**	-0.884**	-0.886**
Soluble sugars (%)	0.918**	0.876**	0.916**	0.854*
Total protein (mg/gm D.W.)	0.901**	0.952**	0.856*	0.906**
N (%)	0.901**	0.952***	0.856*	0.906**
P (%)	0.876**	0.860*	0.884**	0.859*
K (%)	0.977***	0.957***	0.924**	0.893**
Ca (%)	0.909*	0.872*	0.892**	0.843*

*** Significant at 0.05. ** Significant at 0.01. *00 Significant at 0.001.**

The data also cleared that soluble sugars, total proteins, N, P, K and Ca contents were in highly significant (at 0.01 and 0.001 levels) or significant (0.05 level) positive correlation with fruit set % and yield. In contrary, I_1 (Ch_0 / Ch_1), and I_2 (EC_1 / EC_2) index were in highly significant negative correlation with fruit set % and yield.

Such correlations greatly confirmed the essentially of these physiological, biochemical and metabolical basis in estimation and screening tomato genotypes under cold stress condition. At the same time as own and function for maximizing the yield as a final cold tolerance gain.

This suggestion might be confirmed by the findings of Weiser (1970) and Robertson *et al*. (1987) about the involvement of the gene expression alteration during cold stress and thereby the synthesis of cold tolerance-related biometabolites; Auld *et al*. (1983), Norell *et al*. (1986), Gay and Eagles (1991) about the genetically and hertability nature of cold tolerance traits.

At least, it could be emphasized on the advantageous of using one or more of these basis (as a stable, rapid and accurate tool) at one or more

developmental stage to screen for cold tolerance among the different tomato genotypes.

Also, to be utilized from the most cold tolerable genotypes (cold tolerance at all the studied basis), i.e. MHX 668 and LX II to produce cold tolerable varieties for cultivation in cold seasons.

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غربلة بعض طرز الطماطم الوراثية لتحمل البرودة فى العروة الصيفية المبكرة بإستخدام بعض الأسس الفسيولوجية والأيضية السريعة والدقيقة0

السعيد لطفى السيد فتحى

*** قسم بحوث الخضر - معهد البساتين - مركز البحوث الزراعية - القاهرة - مصر**

أقيمت تجربتان حقليتان فى موسمان متتاليان بالمحطة البحثية التابعة لمعهد البساتين بالمنصورة فى العروة الصيفية المبكرة لموسمى 1996/97 و 1997/98 لتقييم وغربلة بعض طرز الطماطم:
(Super Marmand- GR - LX II - US - MHX4953 - MHX975 - MHX668)
للنمو والإنتاج وتحمل الحرارة المنخفضة بالعروة المبكرة بإستخدام بعض الأسس والتقنيات الفسيولوجية والأيضية0 وكانت أهم النتائج كما يلى:-

- إختلاف كل الطرز المستخدمة فيما بينها معنوياً فى سلوكها المورفولوجى وأدائها الفسيولوجى والأيضى تحت ظروف إجهاد الحرارة المنخفضة بالحقل المكشوف0
- كان ترتيبها من الأعلى للأقل فى الصفات المورفولوجية وتراكم المادة الجافة ومحتوى الكلورفيل والبروتين الكلى والسكريات الذائبة والعناصر المعدنية ووزن حبوب اللقاح ونسبة إنباتها والعقد وكمية المحصول ومن الأقل للأعلى بالنسبة لدليلى إستجابات البرودة (تحمل أو عدم تحمل) I_1, I_2 كما يلى:-

MHX668 و LX II و MHX4953 و US و Super Marmand و GR وفى النهاية MHX9 على التوالى وفى كلا الموسمين.

- كان هناك إرتباط إحصائى معنوى موجب بين المادة الجافة والمكونات العضوية والمعدنية ووزن حبوب اللقاح ونسبة إنباتها من جهة ونسبة العقد والمحصول من جهة أخرى0 وكان هناك إرتباط إحصائى معنوى سالب بين دليلى تحمل البرودة I_1, I_2 من جهة ونسبة العقد والمحصول من جهة أخرى0
- كان الطرازين MHX668 و LX II هما أفضل الطرز فى تحمل البرودة والنمو وعقد الثمار والمحصول تحت ظروف إجهاد البرودة السائدة وذلك يرجع لإمتلاكهما لخصائص ووظائف فسيولوجية وأيضية متفوقة فى مراحل النمو المختلفة0 كما يمكن التوصية بالإستفادة منهما فى برامج التربية لإنتاج أصناف متحملة للبرودة أو زراعتهما فى تلك العروة0
- إمكانية الإعتماد على مقاييس وأسس فسيولوجية وأيضية دقيقة وسريعة للتقييم والغربلة لتحمل درجات الحرارة المنخفضة بين طرز وأصناف الطماطم مثل الدليل I_1 (حالة الكلورفيل) والدليل I_2 (الحالة الأيونية والتسرب أو الحفظ الأيونى) وكمية السكريات الذائبة والبروتينات الكلية والمحتوى المعدنى خاصة الفوسفور والبوتاسيوم وكذلك النتروجين والكالسيوم ووزن حبوب اللقاح ونسبة إنباتها (فى مرحلة الإزهار)0

Table (2): Growth (morphological) varifications among different tomato genotypes in early summer seasons of 1996/97 and 1997/98.

Characters / Genotypes	1996/97 season					1997/98 season				
	Plant height (cm)	No. of leaves / plant	No. of shoots / plant	Fresh wt / plant (gm)	Dry wt / plant (gm)	Plant height (cm)	No. of leaves / plant	No. of shoots / plant	Fresh wt / plant (gm)	Dry wt / plant (gm)
GR	44.0 d	38.6 c	7.6 de	412.7 f	63.0 e	46.0 d	36.6 d	7.3 de	418.0 e	66.87 d
Super marmand	66.3 b	38.0 c	9.6 cd	495.7 e	76.4 d	68.0 b	37.0 d	9.3 c	495.3 d	76.0 c
MHX668	75.6 a	85.0 a	14.0 a	1063.0 a	157.8 a	76.0 a	84.7 a	13.2 a	1076.0 a	165.4 a
MHX975	56.3 c	26.0 d	6.3 e	400.0 f	50.13 e	59.6 c	27.4 e	6.0 e	409.3 e	62.7 d
MHX4953	75.6 a	69.6 b	10.4 bc	776.0 c	118.3 b	75.7 a	67.6 b	9.6 c	782.3 b	125.6 b
US	63.3 b	39.3 c	9.4 cd	534.3 d	80.43 c	65.7 b	43.0 c	8.3 cd	532.0 c	79.8 c
LX II	72.3 a	80.3 a	12.0 b	802.3 b	120.4 b	71.6 ab	82.7 a	11.7 b	804.7 b	124.6 b

Means having the same letter in the same column do not significantly differ using Duncan's Multiple Range Test at 5% level.

Table (3). Chlorophyll content (before and after exposure to cold stress, I_1*(Ch_0 / Ch_1), and I_2 (EC_1/EC_2) index of tomato genotypes in during 1996/97 and 1997/98 seasons.**

Characters / Genotypes	Chl. a (mg/gm F.W.)		Chl. b (mg/gm F.W.)		Total Chl. (mg/gm F.W.)		I_1 Index (Ch_0/Ch_1)	I_2 index (EC_1/EC_2)
	Before exp. to cold str.	after exp. to cold str.	Before exp. to cold str.	after exp. to cold str.	Before exp. to cold str.	after exp. to cold str.		
1996/97 season								
GR	35.10 d	20.37 d	46.47 b	14.67 d	81.57 d	35.03 d	2.33 a	0.45 b
Super marmand	26.97 e	18.57 de	22.43 d	11.30 d	49.40 f	29.87 df	1.65 b	0.33 cd
MHX668	87.0 a	84.03 a	90.13 a	60.30 a	177.1 a	144.3 a	1.22 c	0.24 e
MHX975	28.1 e	15.83 e	38.43 c	11.03 d	66.53 e	26.87 e	2.49 a	0.66 a
MHX4953	55.47 b	34.60 c	33.97 c	27.17 c	89.43 c	61.77 c	1.46 bc	0.35 cd
US	38.67 d	15.50 e	27.07 d	14.03 d	65.73 e	29.53 de	2.23 a	0.37 c
LX II	48.9 c	43.03 b	49.6 b	35.77 b	98.53 b	78.80 b	1.25 c	0.30 cd
1997/98 season								
GR	35.53 c	22.17 d	49.60 b	14.40 d	85.13 c	35.57 d	2.32 b	0.45 b
Super marmand	28.2 d	17.00 e	21.07 d	12.13 de	49.27 e	29.13 e	1.69 c	0.36 c
MHX668	90.13 a	79.80 a	87.47 a	58.83 a	177.60 a	138.60 a	1.28 d	0.28 d
MHX975	29.23 d	14.70 e	35.53 c	10.20 e	64.77 d	24.90 f	2.60 a	0.63 a
MHX4953	55.23 b	29.4 c	35.63 c	26.97 c	90.87 c	56.39 c	1.61 c	0.34 c
US	40.10 c	16.07 e	27.90 cd	14.70 d	68.00 d	30.77 e	2.21 b	0.35 c
LX II	55.43 b	41.00 b	47.57 b	34.93 b	103.00 b	75.93 b	1.35 d	0.29 d

Means having the same letter in the same column do not significantly differ using Duncan's Multiple Range Test at 5% level.

*** I_1 (Ch_0/Ch_1) index : Indicator for cold tolerance (low value) or sensitive (high value).**

**** I_2 (EC_1/EC_2) index : Indicator for cold tolerance (value below 0.5) or sensitive (value above 0.5).**

Table (4): Minerals and bioconstituents (total protein and soluble sugars) of tomato genotypes during 1996/97 and 1997/98 seasons.

Characters / Genotypes	1996/97 season						1997/98 season					
	p%	K%	Ca%	Mg%	Total proteins mg/gm DM	Total sugars %	p%	K%	Ca%	`Mg%	Total proteins mg/gm DM	Total sugars %
GR	2.21 d	0.128 f	2.05 f	1.24 e	137.9d	1.61 d	2.10 d	0.130e	2.17 d	1.31 c	129.1 e	1.62e
Super marmand	2.61 b	0.157	2.26 e	1.46de	163.1b	1.93 d	2.51 b	0.154e	2.29cd	1.59bc	156.6 b	2.14d
MHX668	2.93 a	0.286a	2.94 a	2.18 a	182.9a	3.65 a	2.70 a	0.299a	3.03 a	2.45 a	168.9 a	4.05a
MHX975	2.05 e	0.146ef	1.94 f	1.34 e	128.3e	1.85 d	1.99 d	0.149e	2.13 d	1.46bc	124.2 e	2.02d
MHX4953	2.44 c	0.244 b	2.55 c	1.83bc	152.7c	2.64 c	2.30 c	0.230c	2.41 c	1.83abc	143.7 d	2.93c
US	2.38 c	0.188 d	2.38 d	1.66cd	148.9c	2.35 c	2.37 c	0.190d	2.41 c	1.44 c	148.5cd	2.26d
LX II	2.57 b	0.216 c	2.80 b	1.99ab	160.8b	3.22 b	2.40 c	0.253b	2.76 b	2.22ab	150.0 c	3.68b

Means having the same letter in the same column do not significantly differ using Duncan's Multiple Range Test at 5% level.

Table (5): Fruit yield and some parameters during flowering and fruiting stages of tomato genotypes during 1996/97 and 1997/98 seasons.

Characters / Genotypes	1996/97 season					1997/98 season				
	Flower average wt.(gm)	Pollen grain wt. of 5 flowers (gm)	Pollen grain germination (%)	Fruit setting (%)	Yield (Kg) plant	Flower average wt. (gm)	Pollen grain wt. of 5 flowers (gm)	Pollen grain germination (%)	Fruit setting (%)	Yield (Kg) plant
GR	0.0786cd	0.0816 d	13.67 f	28.03 e	1.23 e	0.0747 c	0.0790de	13.10 f	26.77 e	1.16 e
Super marmand	0.1190 b	0.0837cd	16.60 e	36.90 d	1.57 cd	0.1147 b	0.0827 d	16.27 e	35.40 d	1.60 c
MHX668	0.2340 a	0.2310 b	33.37 a	53.97 a	2.17 a	0.2342 a	0.2313 b	33.80 a	52.13 a	2.07 a
MHX975	0.0647 d	0.0628 e	12.43 g	23.20 f	0.95 f	0.0550 d	0.0626 e	12.83 f	21.47 f	0.97 f
MHX4953	0.1243 b	0.1008 c	19.37 c	41.17 c	1.64 c	0.1270 b	0.1007 c	19.30 c	39.47 c	1.58 cd
US	0.0927 c	0.0817 d	17.87 d	37.50 d	1.51 d	0.0887 c	0.0822cd	17.97 d	35.57 d	1.48 d
LX II	0.2233 a	0.3520 a	25.83 b	50.03 b	1.85 b	0.2237 a	0.3433 a	25.00 b	48.03 b	1.81 b

Means having the same letter in the same column do not significantly differ using Duncan's Multiple Range Test at 5% level.