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Tomato Breeding for Heat Stress Conditions

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Abstract. High temperature caused a lot of damage in tomato (*Lycopersicon esculentum* Mill) yield in summer season in Egypt. Tow field experiments were conducted at the experimental farm of Maryout Research Station, Desert Research Center, Alex. Governorate during the summer 2008 and 2009 growing seasons, to evaluate the performance of five different tomato cultivars namely**: Nagcarlang LA-2661**, **Super Marmande**, **Peto-82, UCT5** and **Super Strain-B** and their hybrids to heat tolerance and for screening the cultivars or hybrids under 36.6 / 38.6 ^{0}C day and night 16.6 / 20.3^{0}C during summer season from May to September to produce a new hybrids capable adapted to high temperature with desire characteristics .Results indicated that the highest degree of tolerance was recorded in Nagcarlang LA-2661 value (9.75) followed by the cross UCT5 × Nagcarlang LA-2661 (8.75), while the lowest was recorded in UCT5 cv. Also this result was recorded in fruit set percentage (100%) for LA-2661 and followed by its hybrids UCT5 × Nagcarlang LA-2661 and Super Marmande × Nagcarlang LA-2661 values (87.6% and 76.5%). Significant differences were found among tomato genotypes, Nagcarlang LA-2661 exhibited more tolerance under heat stress conditions. Screening for yield and yield components were recorded, the highest value was 4837.7 g/plant in the cross UCT5 × Nagcarlang LA-2661followed by Super Marmande × Nagcarlang LA-2661 2559.3 g/plant. So, the lowest value was detected in F_1 Peto-82 × Nagcarlang LA-2661. Heterosis expressed the hybrids vigor and exhibited the performance of crosses to heat stress. Data showed that the potence ratio (PR = 2.12% over dominance to yield and high amount of mid parent heterosis (MP = 31.63%) and showed hybrid vigor over better parent where heterosis was BP = 92.64%. Positive correlation among the degree of tolerance and fruit set percentage, fruit number and yield were r = 0.733, o.725 and 0.605 respectively. Selection for vegetative and fruits growth stages were useful tool to heat tolerance.

Key words: Tomato, Heat Tolerance, Correlation, Heterosis, Potence ratio.

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1. Introduction

Tomato (***Lycopersicon esculentum*** Mill) crops is one of the biggest tomato production nations in Egypt and are developed in vast sorts of environments with diverse climatic in the universe from tropical areas to some degree of the Arctic Circle. So, it has a good potential to be confronts a lot of a biotic stress and high temperature is a crucial problem nowadays. [1].

The high temperature during the time of reproductive tomato are caused significant increment in flower drop [2] and significant decrease in fruit set and yield decreased to great extent [3] **.** Heat stresses are the main reasons for poor fruit set at high temperature in tomato. Tomato growth under high temperature is affected adversely on the productive part of the flower, stigma tube elongation, poor pollen germination, poor pollen tube growth and carbohydrate.

Tomato is considered as important and economic agricultural crop at all over the world. For improving the yield and yield attributes, varieties are often produced and evaluated under different environmental conditions. [4] reported that heat stress is rate limiting a biotic factor responsible for reducing tomato yield in the Mediterranean and tropical countries. Tomato production under high temperature conditions, such as the summer in Egypt, reduces the product quality and yield. For instance, low fruit setting, reduction in the flower fertilization rate, decrease in the lycopine content and high evaporation are all related to high temperature stress [5- 8]**,** indicated that heat stress in tomato plants occurred at 35 ^{0}C. This due to decrease weight and accumulation soluble phenolics and reported that the most plants were suffer from both physiological and biochemical damage by exposure to temperature higher and reduced growth capacity of the crops and commercial yield.

The progress in developing heat tolerant tomato cultivars its low heritability values, [9, 10] reported that the heritability values ranged from 5 - 19% and concluded that portion of observable variability among parental lines and their hybrid caused by environmental variables. Physiologists and geneticists express that most stress characteristics are complicated and handled by rather one gene and impacted high environments.

The aim of this study to evaluate the performance of the cultivars under study and there hybrid to heat stress, and select some of one as a new genotype adapted to cultivate under high temperature conditions with desire characteristics.

2. Materials and Methods

Tow field experiments were conducted at the experimental farm of Maryout Research Station, Desert Research Center, Alex. Governorate during the summer 2008 and 2009 growing seasons, to evaluate the performance of five different tomato cultivars namely**: Nagcarlang LA-2661**, **Super Marmande**, **Peto-82, UCT5** and **Super Strain-B** and their hybrids to heat tolerance and for screening the cultivars or hybrids to produce a new hybrids capable adapted to high temperature with desire characteristics. Seeds of cultivar Nagcarlang LA-2661 as a tolerant to heat stress were kindly provided by Prof. Dr. John, I. Yoder, Professor of tomato breeding at the vegetable crops department, California University, Davis, USA. So, the plants described as not determined growth with a lot of branches, fruits are red and small. Also, the seeds of tow cultivars Peto-82 and UCT5 were provided by Dr. R. Chetelat, Professor of tomato breeding at Tomato Genetic Resource Center, California University, Davis, USA and the seeds of Super strain-B and Super Marmande as commercial cultivars and sensitive to heat stress were used.

Before the crossing between the cultivars under study, plants were selfed for two generations and on the 4th of September 2008, Seeds of the five varieties were sown under greenhouse in trays containing mixtures of peatmoss and vermiculite 1:1 percent, and transplanted inside greenhouse during 2008-2009 growing season to obtain the following crosses:

1- **Super Marmande × Nagcarlang LA-2661,**
2- **Peto-82 × Nagcarlang LA-661,**
3- **UCT5 × Nagcarlang LA-2661, and**
4- **.Super Strain-B × Nagcrlang LA-2661**.

On, 15th of April 2009, seeds of the different tomato cultivars and some of their hybrids that obtained F_1\`s were planted separately inside a plastic greenhouse in trays. Seedlings of the different populations were transplanted into the field on the 28th of May 2009.

The experimental were designed in a randomized complete block design with four replications;. Minimum and Maximum temperature degrees with relative humidity, wind speed and solar radiation were recorded daily for six months, form May 2009 to October 2009 and illustrated in Table 1.

2.1 Assessment tolerance degree:

For assessment tolerance degree, some individual plants were screened for high temperature tolerance and kept under summer season 2009. On June, data was recorded on vegetative growth where the scale based on leaf and stem sunburns, leaf rolling and sensitivity of individual plants of all tomato genotypes.

The following data were recorded per plant during the time from 90-120 day.

- Screening tomato genotypes for heat tolerance under high temperature,

- Genotypes evaluation at the vegetative stage under heat stress conditions, where as, the rat of tolerance was classified as the following.

1- Highly heat tolerant from 8–10 degree it was more 80% of plant green, healthy, and good appearance.
2- Moderate to heat tolerant 4-7 degree it had about 50% of leaves sunburns, rolling leaves and drying.
3- Heat sensitive plants 1– 4 degree, most of the plant was susceptible it recorded sunburns in the whole plant leaves, branches drying in leaves, flowers and drying fruit set under high temperature conditions (36.6 / 38.6^{0}C day and night 16.6 / 20.3^{0}C).

The nature cultivars growth was known as a limited, semi limited and non limited growth, this characteristic inherited, it expresses the growth and vigor of plant. The Nagcarlang LA-2662 is non limited growth and heat tolerant

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2.2The following data were recorded on ten randomly plants for each replicate:

- Fruit weight g/plant, fruit number, fruit set, fruit diameter/cm, fruit length/cm, yield per plant g/plant, fruit flesh thickness, locules and the total soluble solids.

2.3. Statistical Analysis:

The experiment was carried out in randomized complete block design (RB) with four replicates.
Statistical Analysis, correlation and calculations of the mean and its standard error for the different characters were estimated according to the methods described by [11, 12].

Table 1: The metrological values of the average monthly for Maximum and minimum temperature recorded at Climatic Maryout Research Station.

Month	*Temperature ^0C*		*relative humidity (RH) %*		*wind speed (WS)*	*Solar Radiation (SR)*	
	Maximum	*Minimum*	*Maximum*	*Minimum*		*Maximum*	*Minimum*
May	36.60	16.60	79.65	49.92	7.377	25.01	13.46
June	38.60	20.30	81.48	52.41	6.417	27.32	14.36
July	38.60	22.80	85.38	64.89	7.474	24.86	12.29
August	30.30	23.10	84.82	63.19	6.21	27.04	15.87
September	29.60	21.30	81.18	57.22	6.757	29.21	19.92
October	27.60	17.80	78.65	52.58	6.239	28.87	20.40

2.4Dominance estimation:

The dominance was calculated according to the potence ratio of gene set (PR) using the following equation that given and described b**y** [13]**.**

Potence Ratio (PR) = F-.P/1/2 (P_2-P_1)

Where:

F = mean, P_1 = mean of smaller parent, P_2 = mean of larger parent and

Mid Parent value M.P. = 1/2 (P2-P1).

3. Results and Discussion

3.1 Screening for heat tolerance:

Tomato genotypes were evaluated to heat stress under field conditions at the summer growing season, where as the temperature were 36.6/38.6^{0}C at the day and 16.6 / 20.3^{0}C at the night. Data presented in Table (2) and figure (1), showed that the significant differences in the degree of heat tolerance based on the scale ranged from 10 (most tolerant) to 1 (most sensitive). The highest value was 9.75 and recorded by Nagcarlang LA-2661cultivar, the genetic resource for heat tolerance followed by its hybrids where values were 8.75 for UCT5 × Nagcarlang LA-2661, Super Marmande × Nagcarlang LA-2661 and 8.75 for Super Marmande cultivar. These results agreement with [14] and reported that performed of Nagcarlang **was** well under heat temperature when grown under greenhouse and field. Also, [15] mentioned that Super Marmande cultivar posses was more tolerance ,On the contrary Super Strain- B was more susceptible, where as the lowest value were 3.5 for UCT5 followed by cv. Peto-82 (4) and Super Strain-B (5). Although it's planted in spring and early of summer season, it was sensitive under long period to heat stress. Earliness could help to avoid the problems associated with high temperature in an area where the temperature rises gradually with onset of summer [16]**.**

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3.2. Measurements for heat tolerance using fruit set percentage and fruit number:

The results presented in Table (2) and figure (1) showed significant differences among the different tomato genotypes concerning fruit set percentage under heat stress conditions (38.6/20-.36/16.6^{0}C day and night). Nagcarlang was the highest value (100%) of fruit set percentage followed by the F_1 s values (87.62%, 86.25% and 75.50%) UCT5 × Nagcarlang LA-2661, Super Marmande × Nagcarlang LA-2661 and Super Strain-B × Nagcarlang. The lowest value (38.48%) was recorded

in cv. cv.UCT5 and was late in flowering and very sensitive to high temperature.

This result agreed with [16] reported that total flower bud production particularly of the first four trusses may be reliable criterion tolerance selection[17] reported that meioses 7-8 days before anthesis is highly sensitive to high temperature, earliness could help to avoid this problem in an area where the temperature rises highly with the onset of summer. Percentage of fruit set varied from 38.45% to 61.50% among different verities except the tolerant parent and its progenies 100% to 75.5% that is suggested by [2, 14], differences existed among cultivars in their ability to transmit their fruit setting ability under high temperature to their intermediate hybrids progenies and high temperature fruit set under the control of additive genes. [18] high temperature regime caused a significant decrease in the number of fruit set in all genotypes related to 32/44 ^{0}C variability was observed among the lines to percent fruit set varied from 21.1% to 52.73%. Data presented in Table (2) revealed the highest number value (100.5) fruit / plant was Nagcarlang LA-2661 it has a large number of small red fruits followed by the values of the crosses (92.75, 63.25 and 55.75) fruits / plant UCT5 × Nagcarlang LA-2661, Super Marmande × Nagcarlang LA-2661,and Super Strain-B × Nagcarlang LA-2661. Whereas the cross Peto82 × Nagcarlang LA-2661 did not super pass the tolerant parent and the different crosses. Significant differences were recorded among different tomato heat tolerant genotypes and sensitive genotypes in screening for heat tolerance under high temperature conditions reached (38.6 ^{0}C /22.8^{0}C day and night)

. The lowest value was measured in UCT5 (12.75) fruit/plant, associated with a large fruit weight, It was followed by Peto82 cv. (19.25) fruit/plant. The results agreed with [14] reported that small fruited cultivars generally produced more fruits and showed a higher level of heat tolerance than large fruited cultivars.

3.3. Screening for heat tolerance on yield and yield components:

Table (2) showed significant differences tomato genotypes in yield and yield components. The highest value in yield (4837.7g/plant) was in the hybrid UCT5 × Nagcarlang LA-2661 followed by the value (2559.3g/plant) of the cross Super Marmande × Nagcarlang LA2-661 and followed by the tolerant parent Nagcarlang LA2661 (2510.52g/plant), while the lowest value was recorded in Peto82 and its hybrid (839.7 and 1070.5g/plant) under heat temperature 38.6/30.3^{0}C day to 20.3/22. 8. ^{0}C.night. [19] reported that compression of varieties for yield revealed that maximum mean fruit yield (2703g) to (66.6g) under high temperature and the rest of genotypes produced 448.3 to (2295.0g /plant) these results suggested that the genotype, which will produce better yield under high temperature conditions would be heat tolerant.

Data revealed obviously variation among tomato genotypes in fruit weight and performance of the tolerant cultivar weight Nagcarlang LA-2661 and the obtained crosses, it was the smallest fruit cv. (20.27g/fruit) followed by the hybrids values (26.33 and 26.37g) for Super Strain-B × Nagcarlang LA-2661 and Peto-82 × Nagcarlang LA-2661. While the large fruited and the highest values was recorded in UCT5 followed by Super Marmande cultivar (109.29 and 82.27 g) respectively, they presented good horticulture tomato varieties for fresh market. Data mentioned to decrease in sensitive varieties under high temperature conditions**.** [20] perceived that morphological traits including fruits and flowers number per crop, percentage of fruit, weight and set were diverse in heat resistant and heat susceptible tomato lines and the outcome were differed in field.

Data presented in Table (2) indicated fruit diameter, length, and fruit quality concerning flesh thickness Total Soluble Solids **T.S.S.,** the highest value of **T.S.S.** (9.6%) was recorded in the cross Peto-82 × Nagcarlang LA-2661 followed by the cross Super Marmande × Nagcarlang LA-2661 (9.25%) while the lowest value (5.5) was recorded in the hybrid in Nagcarlang LA-2661 followed by UCT5, value (6.15%). Total Soluble Solids **T.S.S.** considered as a desire character for fruit quality and aim in selection program.

The results in Table (3) and presented correlation among the degree of tolerance to heat stress, and fruit set fruit numb among the degree of tolerance, yield and yield components.

Data in Table (3) Indicated to positive correlation between the degree of heat tolerance and fruit set percentage, fruit number and yield (r = 0.733, 0.725 and 0.605) where (P = 0.05) in tomato genotypes under high temperature conditions. Addition to positive linear correlation with the nature of determination. Negative correlation was recorded among the degree of tolerance for heat and fruit weight and fruit length (r = - 0.413 and - 0.782[16] reported at the flowering stage positive and highly significant correlation with fruiting stage at all incubations times. Results showed highly significant positive correlation among fruit set percentage with fruit number(r = 0.903) and yield(r = 0.623) while there were negative correlation among fruit set and fruit weight, fruit diameter and high negative linear regression with, fruit length, and number of locules.

Significant positive correlationships were recorded among fruit number with yield (r = 0.766). Also data indicated negative relationships between fruit number and fruit quality (weight, diameter, flesh thickness, locules, and T.S.S.) and highly negative correlation with length (r = - 0.718). Correlation ships indicated a linear decrease in fruit number with increase fruit dimension, fruit quality this due to selection in advanced tomato breeding program based on tolerance with desirable characteristics in fruit quality in recombination to improve tomato varieties to high temperature.

Fruit weight showed highly positive correlation with diameter (r = 0.938), length(r = 0.643) and locule (r = 0.777) these results agreed with [15] reported that correlation between fruit set and yield was positive and highly significant (r = 0.74). Flesh thickness correlated negative and significant with locules, T.S.S., and determination r = - 0.533, - 0.546 The results in Table (3) indicated that slightly significant correlation among the nature of growth determination and the degree of tolerance to high temperature (r = 0.525) and yield (r = 0.574). In contract, the nature of growth determination was recorded negative significant relationship with flesh thickness (r = -0. 653).

Tables (4,5 and 6) the relative potency ratio, mid parent and better parent heterosis in some characteristics.

Heterosis is an important genetic phenomenon with hybrid vigor refers to superiority of the hybrid resulting from the cross genetically heterozygous from

3.4.Heterosis for heat tolerance:

Data in Table (4) indicated relative potence ratio of gene set was moderate and slightly partial dominance towards tolerance to high temperature, value (PR= 0.33) in the cross UCT5 × Nagcarlang LA-2661 and exhibited positive mid parent heterosis (M.R. = 29.63%), followed by the hybrid Peto-82 × Nagcarlang LA-2661 value was (PR= 0.13) and (M.P. = 5.53%). While the other crosses Super Marmande × Nagcarlang and Super Strain-B × Nagcarlang LA-2661 exhibited negative potence ratio of gene set. The F_1 hybrid Marmande × Nagcarlang recorded negative over dominance (PR = - 1.0). Super Strain-B × Nagcarlang LA2661 gave slight negative partial dominance for heat tolerance value was (PR= - 0.15). The previously fourth hybrid showed negative heterosis over better parent (Table 6), where values (BP = - 12.13, -13.75, - 24.5 and - 43) in the crosses UCT5 × Nagcarlang LA-2661, Super Marmande × Nagcarlang, Super Strain B × Nagcarlang LA-2661 and Peto-82 × Nagcarlang LA-2661 relatively. This result mentioned to the superiority of the tolerant parent Nagcarlang LA-2661 to face heat stress and its hybrids did not super pass it.

3.5. Fruit set percentage:

The results presented in Table (4) indicated to high partial dominance for fruit set under high temperature conditions the values were (PR = 0.60 and 0.38) for F_1s hybrids UCT5 × Nagcarlang LA2661, Super Marmande × Nagcarlang, and performed well to heat tolerance, they showed hybrid vigor, heterosis over mid parent (MP = 26.29% and 10.75%) (Table 5). This result agreed with [21] reported that the highest heterotic effect was found in some crosses (62.59% and 60.49%). On the other hand, Super Strain B × Nagcarlang LA2661 and Peto82 × Nagcarlang LA2661 recorded negative potence ratio towards low fruit set values (PR= - 0.27 and -1.8).

3.6. Total yield per plant:

Data in Tables (4,5and 6) showed the hybrid UCT5 × Nagcarlang exhibited the maximum and highest value of potence ratio (PR= 2.12) over dominance for yield and high amount of heterosis over mid parent (MP = 31.63%) and appeared hybrid vigor over better parent heterosis (BP=92.64%) Tables (5,6). Similar findings confirmed by [22] highest heterobeltiosis for fruit yield was (33.74%) followed by 22.14%. The cross UCT5 × Nagcarlang performed well for yield under heat stress conditions, and followed by Super Marmande × Nagcarlang exhibited high partial dominance (PR = 0.82) and showed high mid parent heterosis (MP = 14.62%) and better parent heterosis (BP = 1.94%). The results agreed with [21] reported that hybrids over better parent heterosis ranging from (13.58 to 28.63%) [23, 24] mentioned appreciable heterobeltiosis for yield per plant. [25-27] also reported higher yield in the maximum cross combinations while studying heterosis in tomato. The other crosses showed negative partial dominance value (PR= - 0.85 and - 0.73) in the crosses Super Strain-B × Nagcarlang and Peto82 × Nagcarlang. They also recorded negative mid parent and better parent heterosis values (MP = - 29.95% and -57.35%) and (BP = - 39.44% and -36.1%) respectively.

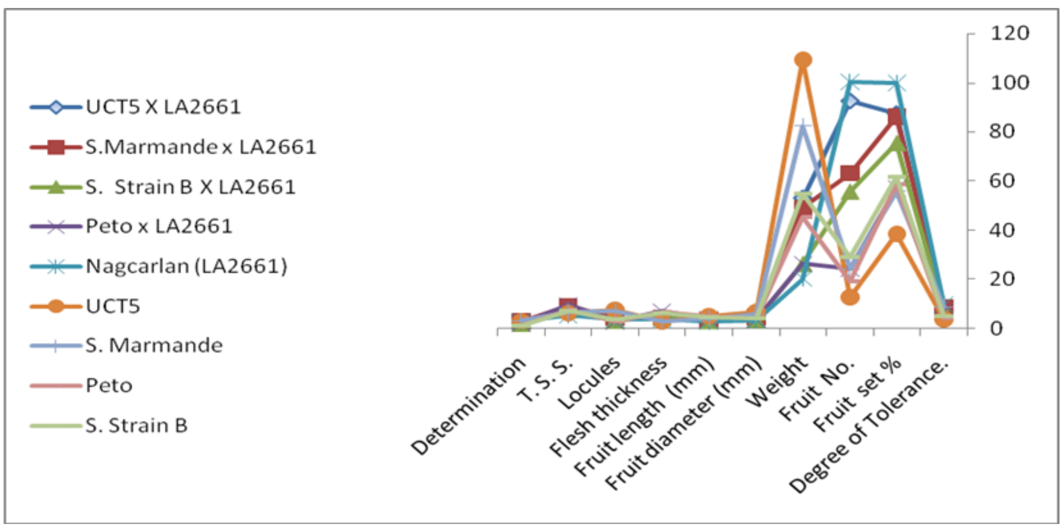

Figure 1: Performance of certain tomato genotypes grown in the field under high temperature during 2009 growing season.

Table 2: Performance of certain tomato genotypes grown in the field under high temperature during 2009 growing season.

Cultivars & its Population	*Degree of Tolerance*	*Fruit set %*	*Fruit No.*	*Yield (g)*	*Weight (g)*	*Fruit diameter (mm)*	*Fruit length (mm)*	*Flesh thickness*	*Locules*	*T. S. S.*	*Determin-ation*
UCT5 × LA2661	8.75	87.62	92.75	4837.70	52.95	4.63	3.63	4.25	3.75	7.55	3.00
S. Marmande × LA2661	8.75	86.25	63.25	2559.3	49.17	4.70	3.55	4.50	4.50	9.25	3.00
SuperStrain-B × LA2661	7.00	75.50	55.75	1520.37	26.33	3.60	3.15	4.50	3.25	7.55	2.00
Peto-82 × LA2661	7.25	57.00	24.25	1070.50	26.37	3.58	3.71	7.00	2.75	9.60	2.00
Nagcarlang LA-661	9.75	100.0	100.5	2510.52	20.27	3.38	2.85	3.50	3.50	5.50	3.00
UCT5	3.75	38.45	12.75	1414.75	109.29	6.60	4.92	2.75	7.50	6.15	3.00
S. Marmande	8.75	55.75	24.25	1955.38	82.27	5.80	4.05	2.75	7.00	6.80	3.00
Peto-82	4.00	58.67	19.25	839.70	45.45	3.90	5.00	6.50	2.75	7.60	1.00
Super Strain-B	5.00	61.50	29.00	1441.00	54.75	3.95	4.50	6.25	3.75	7.20	1.00
L. S. D. 0.05	1.07	9.087	11.77	96.148	11.13	0.36	0.23	0.96	1.09	0.72	0.48

3.7. Fruits per plant:

Considering fruit number per plant Tables (4,5and 6) the hybrid UCT5 × Nagcarlang LA-2661 expressed positive high partial dominance of potence ratio for fruit number per plant under high temperature conditions (PR = 0.823) and it had the highest mid parent heterosis (63.78%). It was followed by the hybrid Super Marmande × Nagcarlang LA-2661 which expressed slight potence ratio of gene set (0.023) and heterosis over mid parent (1.41). While the four crosses UCT5 × Nagcarlang, Super Marmande × Nagcarlang, Super Strain-B × Nagcarlang and Peto-82 × Nagcarlang in the fruit per plant heterosis over better parent were negative values(-7.79%, -37.06%, -44.53% and -75.8%) respectively.

Table 3: Correlation coefficient between the degree of heat tolerance and some traits of yield and its components for tomato genotypes grown under field conditions**.**

Traits	*Resistance*	*Fruit set*	*Fruit no.*	*Yield*	*Fruit Weight*	*Fruit diameter*	*Fruit length*	*Flesh thickness*	*Locule*	*T. S. S*
Fruit set	0.733									
Fruit number	0.725	0.903								
Yield	0.605	0.623	0.766							
Fruit Weight	-0.413	-0.613	-0.495	-0.027						
Fruit diameter	-0.232	-0.498	-0.36	0.067	0.938					
Fruit length	-0.782	-0.688	-0.718	-0.402	0.643	0.467				
Flesh thickness	-0.231	-0.201	-0.347	-0.382	-0.320	-0.359	0.243			
Locule	-0.090	-0.424	-0.309	0.018	0.777	0.758	0.219	-0.533		
T. S. S	0.054	-0.054	-0.167	-0.091	-0.317	-0.247	-0.078	-0.546	-0.394	
Determination	0.525	0.332	0.475	0.594	0.229	0.412	-0.393	-0.653	0.329	-0.179

Table 4: Relative potence ratio (PR) for some characteristics in tomato hybrids under heat stress conditions.

Cross	*Resistance*		*Fruit set*		*Fruit number*		*Yield g/plant*	
	Mean	*PR*	*Mean*	*PR*	*Mean*	*PR*	*Mean*	*PR*
UCT5 × LA-2661	8.75	0.33	87.62	0.60	92.75	0.83	4837.7	2.12
S. Marmande × LA-2661	8.75	- 1.00	86.25	0.38	63.25	0.23	2559.3	0.82
S. Strain B × LA-2661	7.00	- 0.15	75.50	-0.27	55.75	- 0.25	1520.37	-0.85
Peto-82 × LA-2661	7.25	0.13	57.50	-1.80	24.25	-0.88	1070.5	-0.73

Table 5: Mid Parent heterosis for some characteristics in tomato hybrids under heat stress conditions.

Cross	*Resistance*		*Fruit set*		*Fruit number*		*Yield g/plant*	
	Mean	*MP%*	*Mean*	*MP%*	*Mean*	*MP%*	*Mean*	*MP%*
UCT5 × LA-2661	8.75	29.63	87.62	26.29	92.75	63.78	4837.70	31.63
S. Marmande × LA-2661	8.75	- 5.40	86.25	10.75	63.25	1.41	2559.30	14.62
S. Strain-B × LA2661	7.00	- 5.02	75.50	- 6.50	55.75	-13.89	1520.37	-29.95
Peto-82 × LA2661	7.25	5.53	57.50	- 29.64	24.25	- 59.48	1070.50	-57.35

Table 6: Better Parent heterosis for some characteristics in tomato hybrids under heat stress conditions**.**

Cross	*Resistance*		*Fruit set*		*Fruit number*		*Yield g/plant*	
	Mean	*BP%*	*Mean*	*BP%*	*Mean*	*BP%*	*Mean*	*BP%*
UCT5 × LA-2661	87.62	-10.26	87.62	-12.38	92.75	-07.71	4837.70	92.69
S. Marmande × LA-2661	86.25	-10.26	86.25	-13.75	63.25	-37.06	2559.30	1.94
S. Strain-B × LA2661	75.50	-24.41	75.50	-24.50	55.75	-44.53	1520.37	-39.44
Peto-82 × LA-2661	57.50	-25.64	57.50	-43.00	24.25	-75.87	1070.50	-36.10

4. Conclusion

In tomato breeding program, screening and selection genotypes to heat tolerance are useful tool at the vegetative and fruited stage. In this study, Nagcarlang LA-2661 cultivar is consider one of the main importance genetic resources for heat tolerance and recorded the well performed, and needs to focus on the desirable characteristics such as fruit weight. So, its fruits are small, this due to have the inherited trait from tolerant parent and we can improve this trait and fruits quality by using backcrosses hybridization with some desirable commercial cultivar through breeding program.

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References

[1] F. Golam, Z. H., Prodhan, A. Nezhadahmadi, M.Rahman, Heat Tolerance in Tomato. Life Science Journal.9(4).1936-1950, 2012 .

[2] H. Y.Hanna, and T. P. Hernandez, Response of six tomato genotypes under summer and spring weather conditions in Louisiana. Hort. Sci., 7:758-759, 1982 .

[3] S. Z. Berry, and M. Rafique –U.d-Din, Effect of high temperature on fruit set in tomato cultivars and selected germplasm. Hort. Sci., 23: 606–608, 1988.

[4] A. Mansour., H. M. Ismail, M. F Ramadan,. and G.J., Gyulai, Variations in tomato (*Lycopersicon esculentum*) cultivars grown under heat stress. Verbr. Lebensm:118 – 127, 2009 .

[5] K. Al-Khatib, and G. M. Paulsen, High-temperature effects on photosynthetic processes in temperate & tropical cereals. Crop Sci. 39: 119 – 125, 1999.

[6] A. E.Hall, and L. H. Ziska, Crop breeding R. and Hodges, H. F. (eds.) Climate Change and Global Crop Productivity, CABI Publishing, New York, USA,pp: 407– 423, 2000 .

[7] A. E Hall, Crop Responses to Environment. CRC Press LLC, Boca Raton, Florida. 2001.

[8] R. M. Rivero, J. M. Ruiz P.C. Gario, Lopez- L.R .Lefebre, E.Sanchez, and L.Romero, Resistance to cold and heat stress: accumulation of phenolic compounds in tomato and watermelon plants. Plant Science160, 315-321, 2001.

[9] A. A. Abdul-Baki, Tolerance of Tomato Cultivars and Selected Germplasm to Heat Stress J. AMER. Soc. Hort. Sci. 116 (6):1113-1116, 1991 .

[10] R. L. Villareal, Lai, S.H. and S. H. Wong, Screening for heat tolerance in the genus *Lycopersicon*. 13: 479-481, 1978.

[11] K. A. Gomez, and Gomez, A. A. Statistical procedures for agriculture research. John Willy & Sons. Inc. New York, USA. 1984.

[12] N. F. Briggs, and P. F. Knowles, Introduction to plant breeding Reinhold Publishing corporation.USA, 1977.

[13] H. H. Smith, Fixing transgressive vigor in Nicotiana rustica In Heterosis, Iowa state college press Ames. Iowa, USA. 1952.

[14] F. A. Dane, Gene Hunter, and Oyette L. Chambliss. Fruit Set, Pollen Fertility, and Combining Ability of Selected Tomato Genotypes under High temperature Field Conditions. J. AMER. Soc. Hort. Sci. 116 (5): 906-910. 1991.

[15] M. A. S. Kamal, S. Soliman, A. E. Mandour and S. S. Ahmed, Genetic Evaluation and Molecular Markers for Heat Tolerance in Tomato (*Lycopersicon esculentum* Mill.) Journal of American Science. 6 (12), 364-374, 2010.

[16] A. Alsadon, M. A. Wahb-allah, and S. O. Khalil, In vitro Evaluation of Heat Stress Tolerance in Some Tomato Cultivars. J. King Saud Uni. Vol. 19, Agric. Sci. (1) pp.13-34, Riyadh 1427H, 2006.

[17] G. Kalloo, Breeding for environmental stress in tomato. In: G. Kalloo (ED), Genetic Improvement of Tomato Berlin: 153-166, 1991 .

[18] K. Srivastava, S. Kumar, S. kumar, P. Prakash and A. Vaishampayan. Screening of Tomato Genotypes for Reproductive Characters Under High Temperature Stress Conditions. SABRAO Journal of Breeding and Genetics, 44 (2): 263-276. 2012.

[19] K. Asif Saeed, Hayat, Asif. A., Khan and S. IQBAL. Heat Tolerance Studies in Tomato (***Lycopersicon esculentum*** Mill.) strategies for the 21st century. In: Reddy, K. Journal of Agriculture & Biology 9 (4): 649 – 652. 2007.

[20] A .H. A. Abdel-Mageed, and N. Gruda, Performance of different tomato genotype in the arid tropics of sudan during the summer season. 2, Generative development, Journal of Agriculture and Rural Development in the Tropics and subtropics, 11012?/2 147-154. 2009.

[21] M. M. Alam Patwary, S. Rahman, , M. M. Ahmad M. A Khaleque miah. and H. Barua, Study of heterosis in heat tolerant tomato (*Solanum lycopersicum*) during summer. ISSN 0258-7122, Bangladesh J. Agric. Res. 38 (3): 531-544. 2013.

[22] S. K. Yadav, Singh, B. K., Baranwal D.K., and Solankey, S.S.Genetic study of heterosis for yield and quality components in tomato (*Solanum lycopersicum*). African Journal of Agricultural Research. 8 (44): 5585-5591. 2013

[23] A. A. Hassan, S. E. S. Moustafa, A. K. Abdel and Mohammad, A. A. Development and release of some new tomato (*Lycopersicon esculuntum* Mill.) hybrids. Egyptian J. Hort. 27 (2): 210-218, 2000.

[2 P. R. Dharmatti, B. B. Madalgeri, I.M. Mannikeri, R. V. Patil, and Patil, G. Genetic divergence studies in summer tomatoes. Karnataka J. Agric. Sci. 14 (2): 407- 411. 2001.

[25] I. El-Mahdy, E-Metwally, G. El-Fadly and. Mazrouh, A.Y. Inheritance of yield and fruit setting quality of some tomato crosses grown under heat stress conditions in Egypt. J. Agric. Res. Tanta Univ. 16 (3): 517-526, 1990.

[26] S. Ahmad, Genetics of fruit set and related traits in tomato under hot humid conditions. Ph. D. Thesis. Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur, pp.1-236. 2002.

[27] S. Ahmad, A. K. M. Quamruzzaman and Islam, M. R. Estimate of heterosis in tomato (*Solanum lycopersicum* L.).ISSN: 0258-7122 Bangladesh J. Agril. Res. 36(3): 521-527, 2011.

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