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STUDY ON THE HEAT TOLERANCE IN TOMATO (LYCOPERSICONE SCULENTUM MILL.) AT HYDERABAD, SINDH

Muzamil Hussain Awan
Department of Plant Breeding and Genetics, Sindh Agriculture University, Tandojam, Pakistan

Jawad Ahmed
Department of Plant Breeding and Genetics, Sindh Agriculture University, Tandojam, Pakistan

Asif Ali Kaleri
Department of Agronomy, Sindh Agriculture University, Tandojam, Pakistan

Noman Asghar
Department of Plant Breeding and Genetics, Sindh Agriculture University, Tandojam, Pakistan

Saba Solangi
Department of Plant Breeding and Genetics, Sindh Agriculture University, Tandojam, Pakistan

Ahmed Ali
Department of Plant Breeding and Genetics, Sindh Agriculture University, Tandojam, Pakistan

Faiza Bibi
Department of Plant Breeding and Genetics, Sindh Agriculture University, Tandojam, Pakistan

Abdul Sattar
Department of Plant Breeding and Genetics, Sindh Agriculture University, Tandojam, Pakistan

Nabeela Rashid
Department of Plant Breeding and Genetics, Sindh Agriculture University, Tandojam, Pakistan

Duaa Akbar
Department of Plant Breeding and Genetics, Sindh Agriculture University, Tandojam, Pakistan

Corresponding author: Asif Ali Kaleri (asifalikaleri2013@gmail.com)

Article Info

Abstract

Present study was conducted to analyse the heat tolerance and correlation estimates in Tomato (Lycopersicon esculentum Mill.) at Hyderabad, Sindh. The data was collected for membrane thermostability, elongation of stigma and antheridial cone splitting, flowers no. and number of flowers shed per plant and production per plant was under the study. The data revealed significant differences among the studied traits. Among the genotypes, (1) Fanto F1 Hybrid exhibited the highest heat tolerance, followed by was (2) Hybrid tomato HT-101B, as evidenced by their high membrane thermostability and low number of flowers shed. These genotypes also demonstrated the highest fruit yield during the hot period. The analysis showed a positive association between fruit yield and membrane thermostability, while a negative association was observed with the number of flowers shed, stigma tube elongation, and antheridial cone splitting. In summary, Roma, with the lowest membrane thermostability, was found to be the most sensitive genotype to heat stress.

Keywords: *Heat tolerance, Membrane thermostability, Tomato, Sindh.*

Introduction

The tomato (*Solanum lycopersicum*L.) holds a significant position among vegetables, featuring prominently in various traditional dishes due to its harmonious pairing with other ingredients and its notable nutritional and antioxidant content. Belonging to the Solanaceae family, tomatoes exhibit a unique versatility, serving as both a fresh vegetable and a key component in processed products like juice, ketchup, sauce, canned fruits, puree, and paste. Annually, approximately 171 million tonnes of tomatoes are harvested from plantings covering 5 million hectares. The global production distribution reveals that Asia contributes nearly 60%, Africa 11.1%, Europe 13.3%, North America 8.7%, and Central America and South America a combined 6.6%. In 2014, the leading tomato producers worldwide were China, India, the United States, Turkey, and Egypt, as reported by FAOSTAT in 2017. Tomatoes were cultivated on a global scale, covering an expansive 4.85 million hectares, resulting in a total production of 182.30 million tons. China emerged as the foremost producer, trailed by India and Turkey. In contrast, Pakistan secured the 36th position in the global rankings, contributing a modest 0.33% to the overall production. Within Pakistan, tomatoes were cultivated across 0.06 million hectares, yielding 0.58 million tons at an average rate of 9.49 tons per hectare. This yield, comparatively lower than that of other nations, was reported by FAO in 2017. The capacity of a crop plant to endure adverse conditions while sustaining its yield represents a form of resistance to stress, as indicated by studies conducted by Bokszczanin et al. (2013), Zhou et al. (2015), and Rathod et al. (2018). Although tomatoes are generally considered a tropical crop, their production, along with that of other crops, is significantly diminished by heat stress. The optimal growth conditions for tomatoes involve a daily mean temperature ranging between 19-24°C, a range that is also influenced by the developmental phase of the crop, as highlighted by Giri et al. (2017). As the temperature surpasses the optimal range, there is a decline in both fruit set and seed production in tomatoes, as documented by Zhou et al. (2015) and Nduwimana and Wei (2017). Additionally, elevated temperatures contribute to floral abscission, diminished pollen quality, reduced fruit setting characterized by smaller-sized fruits, and irregularities in plant growth and development, as observed in studies by Hasanuzzaman et al. (2013) and Khondakar et al. (2017). The majority of tomato cultivars are vulnerable to high temperatures, posing a significant challenge for cultivation, especially in regions where temperatures reach or exceed 38°C for brief periods during the growing season, as outlined by Nazir et al. (2017). Consequently, there is a pressing need to comprehensively grasp the developmental, reproductive, and physiological performance of crop plants in response to stress. This understanding is crucial for effectively addressing potential alarming situations in the future, as emphasized by Karapanos et al. (2009). The objective of this study is to identify and assess heat-tolerant genotypes of tomatoes that can be cultivated during periods of scarcity and under high-temperature conditions. These genotypes may also serve as valuable parental lines in various breeding programs, especially those focused on heat-related traits and other characteristics of significance. Elevated temperatures can lead to a breakdown in membrane integrity, impairment of primary photosynthetic processes, alterations in lipid composition, and denaturation of proteins (Wahid et al., 2007). The imperative at present is to create cultivars with enhanced heat tolerance, addressing the necessity to acclimate to both current and anticipated rises in heat stress (Bita, 2013; Solh, 2014; De la Pena, 2013). Nonetheless, the challenge of breeding for heat tolerance is heightened by the intricate nature of plant response mechanisms to stress (Hedhly, 2013) and the limited exploration of the genetic foundations of heat tolerance traits and sub-traits in tomatoes (Driedonks et al., 2016). The success of the heat tolerance breeding program relies on the effective identification and characterization of traits associated with fruit set under heat stress (De la Pena, 2013; Driedonks et al., 2016). This study aims to enrich breeders' understanding of the fundamental mechanisms by presenting information on morphological, physiological, and genetic resources related to heat tolerance. It will facilitate the selection of breeding materials, streamline efficient screening processes, and inform the adoption of suitable breeding methods.

Material and Method

Experimental data used in this study to evaluate the temperature resistance of tomato (L. esculentum Mill.) including (1) Fanto F1 Hybrid, (2) Hybrid tomato HT-101B, (3) T-10, (4) Peshwari, (5) Golo, (6) Hoop, (7) Aharo, (8) Roma hybrid, (9) Rio Grande and (10) FM9. The experiment was conducted in the Vegetable Experimental Field of Department of Plant Breeding and Genetics, Sindh Agriculture University, Tandojam,. All strains obtained from the nursery were transplanted to the field in triplicate in a completely random design. Plant the seedlings in rows with 10 plants in each row, keeping the distance between rows and plants at 60 cm and 30 cm respectively. While the information is taken from the 5 plants in the middle, the plants are located on both sides of the line so as not to disrupt the border. Use agricultural practices and plant protection to ensure healthy plants. Film thermal stability of experimental data during the flowering period Thermal resistance (MTS) Use of electrolyte leakage from leaf tissue as previously described in tomato (Saeed et al., 2007). In addition to the MTS tests below, there are also parameters such as number of flowers per plant, stigma elongation, anther cone cleavage, number of flowers burned/removed, date in fruits and vegetables. Yield per plant is also used to measure temperature tolerance. Parameter measurements were made in June-July at an average temperature of 42 - 45oC.

Statistical analysis. All trait data were analyzed after application of analysis variance technique. Steel and Torrie's (1980) simple linear correlation between the characters, as well as regression analysis of yield with respect to other trait was also performed.

Result and Discussion

Anth radial cone splitting:

The results regarding the antheridial cone splitting were recorded significantly difference among various under observation genotypes. The results for heritability estimates was observed 0.7723, that proved (77%) of change among observed genotypes, that was confirmed by Table-2. The Table-2 proved that 9 genotype showed maximum 39.21%, where genotype 2 has lowest results for this trait. The findings indicated that genotypes with low number of flower are associated with maximum strong and stable in maximum temperature. It is suggested that anther having a greater number of split will not be able to produce viable pollen and this will negatively effect on the production of fruit and final yield.

Heat tolerance measurement with the help of (MTS) Membrane Thermostability:

In this study results was observed highly significant difference for heat tolerance with help of membrane thermostability by using electrolytes method showed that gentyes in the Table-1. The comparative results for membrane thermostability reported that 2 genotypes had maximum 25.81 results and genotype 8 had lowest values for 5.31. The remaining genotypes showed results for membrane thermostability varies from genotype to genotype with having positive and strong variety, details are given in Table-1. The results showed that membrane thermostability are high respond to high temperature and associated with more exposure to high level of temperature have damaging influence on the leaf and tissue of tomato plant reported by (Nahar et al., 2015 and Hussain et al., 2006).

Elongation of stigma tube:

Vijayakumar et al. 2021) revealed that the tomato crop is greatly self-pollinated and this process could not be increased up to1- 2 percent level. It is reported by (Mahmood et al., 2021), that during the high environment temperature the flowers of stigma tube expands out from the cone antheridia and thus stop the process of pollination and result shows the reduction in the tomato fruit. Albert et al., (2016) and Akhtar et al., 2017), revealed 1 mm elongation of stigma tube cause reduction in fruit production of crop and also reported negative and low estimates for correlation among elongation of stigma tube in tomato crop production. The findings of present depicted significant P<0.05) between various genotypes regarding the elongation of stigma tube in Table-1. Whereas the results for heritability and variability were 0.6798 and 8.71%, details are in Table-1. The result suggested little bit proportion of variation among traits can be observed. In this 20 to 50% of elongation of stigma tube were in this average. The 10 variety showed maximum values 53 and 24%. This showed a significant difference among the data presented in Table-2. The flowers of tomato crop in elongation of stigma tube showed less pollination process and showed less production per plant. It is therefore suggested that genotype produce flowers with normal elongation of stigma tube in the high temperature decrease and product more production in the form of flower, fruits and tomato (Abdalla t al., 2020).

No. of flowers shed/crack:

The analysis of mean squares for the number of flowers shed per plant revealed a high level of significance (Table 1), indicating that there were significant differences observed among the ten tomato genotypes in their ability to retain flowers under high temperature conditions. Furthermore, the character exhibited a high broad sense heritability value of 0.7373, suggesting that a substantial portion of the variation in this trait can be attributed to genetic factors. The data revealed significant variation among the 10 variety in terms of the number of flowers shed Table-2. Genotype Cchaus exhibited the lowest number of flowers shed, with a value of 15.00, while genotype 4 had the highest number of flowers shed, with a value of 36.30 (Table -2). The remaining genotypes had mean values ranging from 26.20 to 33.40. These findings suggest that genotypes 1, 2 and 3 with flower shed percentages of 2521, 2176 and 1987, respectively, retained more flowers at high temperatures, indicating a potential for higher yield. (Nahar et al., 2015) also noted that increased temperatures can lead to an increase in flower drop per plant, resulting in reduced yield.

Fruit production/ yield/ plant:

The average values of mean square for various verities were significantly difference for production per plant in high temperature environment Table-.1 The results showed that variation between varieties 0.7561, high genetic level base. The findings for coefficient of variability was recorded 6.7%. The findings of our study showed that the variety that produce more production during higher temperature surely have resistant to heat tolerant. This is suggested that these genotypes can be highly productive and cultivated in high temperature zone for better production and growth of tomato crop.

Tabel-1 The result for average mean performance of different heat stress related traits

	Average mean			+	++
Character	**Replication**	**Genotype**	**Error**		
Anth radial cone splitting	42.689	176.345	17.534	0.7723	13.47
Membrane thermostability	5.432	128.342	2.910	0.7544	11.51
Elongation of stigma tube	12.432	297.794	12.875	0.6798	8.71
No. of flowers shed/crack	1.345	117.457	1.976	0.7373	4.975
Yield per plant (g)	57543.196	1737981.632	15977.143	0.7561	8.79

Table-2 The result for comparison of various genotypes of for different heat stress related traits

Genotype	Anth radial cone splitting	Membrane thermostability	Elongation of stigma tube	No. of flowers shed/crack	Yield per plant (g)
(1) Fanto F1 Hybrid	23.01	19.43	31.32	13.87	2521
(2) Hybrid tomato HT-101B	17.11	25.81	28.27	23.76	2176
(3) T-10	19.00	17.32	20.71	12.32	1987
(4) Peshwari	23.34	14.32	24.21	29.17	1976
(5) Golo	19.15	11.17	35.76	30.57	1471
(6) Hoop	29.00	12.37	27.12	27.75	1453
(7) Aharo	33.21	8.29	40.25	27.71	9071
(8) Roma hybrid	35.09	5.31	87.37	33.31	794.5
(9) Rio Grande	39.21	11.71	50.34	35.22	357.7
(10) FM9	33.37	3.81	53.98	31.09	55.9

The correlation estimates among yield and various floral traits in Tomato crop in high temperature environment (MTS) Membrane Thermostability:

The results for correlation estimates showed in Table-3 suggested that in the high temperature membrane thermostability was observed correlated positively with tomato yield 0.763. The correlation showed that increased in number of fruit production will increase the membrane thermostability shown in Table-3. These results are in agreement with results of (Argyris et al., 2005 and Arah et al., 2015)

Tabel-3. Correlation estimates between various traits related to heat stress

Trait	Membrane thermostability	Elongation of stigma tube	Anth radial cone splitting	No. of flowers shed/crack	Yield per plant (g)
Membrane thermostability					0.763
Elongation of stigma tube	0.653			0.590	-0.789
Anth radial cone splitting	-0.697	0.769		0.590	-0.756
No. of flowers shed/crack	-0.597				-0.785

Elongation of stigma tube:

The results for correlation estimates was observed negative among yield and flowers of elongation of stigma tube in Table-3. These results supported by results of Hernandez, (1982) and Ahmadi & Stevens, (Kugblenu et al., 2014).

Anth radial cone splitting:

In Table-3, a negative correlation coefficient of -0.697 was observed between yield and the number of flowers with splitted antheridial cone. This finding is consistent with previous reports by Haque et al. 2021; Guo et al. 2022) and Dane et al. (1991) that also observed a similar trend.

No. of flowers shed/crack:

In Table-3, a negative correlation was observed between the number of flowers shed and the yield per plant. These findings align with previous studies conducted by Argyris et al, (2005) and Arah et al. (2015), indicating a similarity in results.

Conclusion

Tomato plants exhibit variation in their ability to tolerate heat stress. While the assessment was conducted on a limited number of germplasm, it was observed that different genotypes displayed varying levels of tolerance to heat stress. Notably, the genotypes (1) Fanto F1 Hybrid and (2) Hybrid tomato HT-101B exhibited a higher degree of tolerance. This suggests that there is potential for breeding tomato genotypes that possess enhanced heat stress tolerance, which would be beneficial for sustaining tomato production in hot conditions.

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