

## EVALUATION OF TOMATO GERMPLASM ADAPTABLE TO ABIOTIC STRESS CONDITIONS OF NORTHERN INDIA

Umesh Chandra and P.N. Gupta

National Bureau of Plant Genetic Resources  
Pusa Campus, New Delhi 110 012

Over large areas, tomato production in India is being adversely affected by less favourable environmental conditions (abiotic factors) such as low and high temperature, drought, flooding and soil salinity. The National Bureau of Plant Genetic Resources (NBPGR), over the years, has assembled ca 2900 germplasm lines from diverse agro-climatic zones of the world (over 45 countries) and from within India. This includes several wild species viz., *Lycopersicon pimpinellifolium*, *L. hirsutum*, *L. cheesmanii*, *L. peruvianum*, *L. glandulosum*, *L. chilense*, *L. chmielewskii*, *L. parviflorum*, *L. esculentum* var. *cerasiforme*, *L. hirsutum* f. *glabratum*, *L. peruvianum* var. *humifusum*. Development of resistant cultivars against abiotic factors is an economical proposition. Realising possibilities of use of stress resistance, the germplasm were tested/evaluated under field conditions during hot summers (April-June) in Delhi (max. temp. 40° - 44°C) and attempts were made to identify germplasm pertaining to definite sources of resistance i.e., ability for tolerance to temperature stress, drought conditions and reaction to diseases and pests, to develop lines possessing resistance to stress and other propositions. Evaluation studies (at Delhi when temperature is about 38°-40°C) revealed that 46 accessions are heat tolerant/moderately heat tolerant including the wild species, 21 of processing types, 12 accessions suitable for transportation and 29 and 56 accessions are resistant/tolerant to diseases and fruit borer, respectively. Forty accessions were scored for high yielding potentiality. *L. pimpinellifolium* required more number of days for expressing wilting, thus showing tolerance to drought conditions. Wild species *L. esculentum* var. *cerasiforme* - tolerant to stress, *L. hirsutum* - tolerant to drought) possess resistance to abiotic factors.

**Key words :** Tomato, *Lycopersicon* sp., evaluation, heat tolerance, disease resistance, donor germplasm

Tomato is one of the most widely grown vegetable crops in India. It occupies an area of over 82,000 ha with a total production of 802,000 t and an average yield of 9.78 t/ha. Over large areas, tomato production in the country is being adversely affected by less favourable environmental conditions (abiotic factors). Generally high and low temperature, drought, excessive moisture, salinity and alkalinity are associated conditions which limit tomato production. Development of resistant cultivars against these abiotic factors is an economical proposition. The possibility of use of stress resistance has been realised and attempts are made to identify donor germplasm pertaining to definite sources of resistance to develop lines possessing resistance to stress.

### GERMPLASM ASSEMBLAGE AND PRELIMINARY EVALUATION

The National Bureau of Plant Genetic Resources (NBPGR), over the years, has assembled *ca* 2900 germplasm lines on systematic basis from diverse agro-climatic zones of the world (from over 45 countries including Taiwan) and from within India. This includes several wild species viz., *L. pimpinellifolium*, *L. hirsutum*, *L. peruvianum*, *L. chessmanii*, *L. pissisi*, *L. glandulosum*, *L. chilense* and *L. esculentum* var. *cerasiforme* *L. hirsutum* f. *glabratum*, *L. peruvianum* var. *humifusum* and *L. chmielewskii*. Realising possibilities of use of stress resistance and other traits, the germplasm were tested/ evaluated under field conditions in a phased manner (Thomas and Umesh Chandra, 1989a; *ibid*, 1989b; 1993; NBPGR, 1991) during hot summers (maximum temperature  $\pm$  38 – 42°C) at NBPGR Experimental Farm, Issapur (latitude 28° 35'N; longitude 70° 18'E; altitude 226. 16m above msl; annual rainfall 400mm; soil texture-sandy loam and pH 6.5 – 8.2) in Delhi. Each accession was grown in 2 rows plot of row length 4m and row to row distance 60 cm, during summer seasons of 1990, 1991 and 1992 in augmented block design. Donor germplasm pertaining to definite sources of resistance, i.e., ability for tolerance to temperature stress, drought condition (Table 1), resistance/tolerance for reaction to *Fusarium* wilt and fruit rot and to fruit borer and other attributes like high yield potential, large fruit size, fresh market types, processing types and suitability for long shelf life (Table-2) were identified to develop lines possessing resistance to stress and other propositions. For enhancing the adaptation of this vegetable to the hot humid tropical/sub-tropical condition of India, tomato breeding programme can be achieved with the help of these donor germplasm to develop breeding lines carrying heat tolerance, resistance to diseases, improved fruit size and better external fruit quality such as firmness and resistance to cracking etc.

**Table 1. Genetic resources for heat, drought tolerance in tomato and related wild species**

Attributes	Donor Germplasm
Genotypes setting fruits at high temperature (43 accessions)	EC number : 1127, 4639, 11960, 16465, 27910, 31515, 35446, 37226, 37284, 89248, 94181-6, 106265, 110578, 114503, 122063, 125754, 130042, 130053-1, 162598, 162935, 163690, 163704, 164636, 164666, 165393, 165700, 165751, 168064, 168070, 168281, 169308, 170662, 251636, 251674, T-41, NC-57299, PI-205009, <i>L.cheesmanii</i> , <i>L.pimpinellifolium</i> - Pan American, Punjab Tropic, Merz, HS-101, HS-102.
Drought tolerant	EC numbers : 65992, 104395, 130042, Sel-28, <i>L. pimpinellifolium</i> (PI-205009)

EC numbers represent exotic collections obtained from other countries and maintained at NBPGR, New Delhi - 110 012, India.

### HIGH TEMPERATURE TOLERANCE

Heat tolerance is measured by the ability of the plant to set fruits under high temperature. Growing hot summer season tomatoes is a common problem in India and elsewhere. Generally when temperature exceeds  $\pm 32^{\circ} - 35^{\circ}$ , depending on the variety, flowering and fruit set are adversely affected in tomato. Fruit set is one of the sensitive stages at high temperatures and this area has been given adequate treatment in respect of screening of germplasm to isolate appropriate sources of resistance. The germplasm were screened in the natural stress environment when conditions become less than optimum. Generally under such natural stress conditions, a germplasm line, if performs well, it may be considered stress tolerant, for example growing tomato in summer for screening of fruit set at high temperature is a direct selection.

Table 2. Donor Germplasm in tomato for breeder's use

Traits	Notable accessions
Heavy fruiting types	EC numbers : 31515, 101652, 106625, 110578, 118292, 129081, 129354, 130053-1, 145515, 163591, 163598, 170373, 170662, 173856, 232427, 238307, 246028, 251538, 251558, 253271, 267725, 283538, 283539, 277690, 277696, 294697, 6049, 281060, IC-90604 and IC-90905
Larger fruits	EC numbers : 212469, 246028, 232429, 232436, 144295, 168070, 159038, 163671, 165893, 253263, 25364, 253271, 11960, 125754, 267728, 251606, 251751 and 267725.
Fresh market types	EC numbers : 260628, 177294, 232429, 241153, 161245, 168070, 35520, 200676, 7286, 25169, 41025, 32611, 6049, 164660 and A-1.
Processing types	EC numbers : 126776, 12754, 4708, 11960, 12527, 129600, 159966, 1154, 2790, 8822, 232, 427, 241150, 246028, 159038, 164677, 177824, 163611.
Long shelf life	EC numbers : 161252, 7352, 100845, 110268.
Mimic type	EC 251679
Nematode resistant	NT-3, NT-8 and NT- 12, Nemerred, Nematex, Atkinson, Pusa-120.
Resistant to wilt, fruit rot and early blight	<i>L. pimpinellifolium</i> (EC-65992, 65993, 86517, 86522, 7353, 121453)
Resistance to Leaf curl, Fusarium wilt and fruit rot	<i>L. hirsutum</i> (EC-486, 65999, 127985) <i>L. peruvianum</i> (EC-2630)
Resistance to Fusarium wilt and Fruit rot	<i>L. pimpinellifolium</i> x <i>L. esculentum</i> EC- 66007, 86516, 99935, 106295, 116039 and 128013).
Resistance to Fruit borer	EC- 129354, 124406, 129599, 66005, 118266, 114947, IC-59067.

IC numbers represent collections from India

There was a wide range of variation among genotypes for fruit set under high temperature conditions and the evaluation studies (at Delhi when temperature of about 38 - 40°C) reveals that 43 accessions set fruits at high temperature (Table-1). In addition, the fruit set was recorded at high temperature by several workers for example in Saladette (Leeper, 1974), L-125, L-226, L-232, L-2972 (Villareal *et al.*, 1978); *L. pimpinellifolium* (Villareal and Lai, 1979; Rana and Kalloo, 1989a); BL-6807, S-6916, CL-5-0-0-1 and Saladette (Hanna and Hernandez, 1982); PS 84 # 84, *L. cheesmanii*, EC-130042 and EC-162935 (Rana and Kalloo 1989a) and Land point (84#42), PS Mini Rose (84#58), PI-205009 and *L. pimpinellifolium* Pan American (Kalloo and Banerjee, 1990). Cultivar Philippines could set fruit even upto 44°C (Chaudhary, 1973). However Punjab Tropic, Merz, P-4 and F1 hybrids have shown good performance under high temperature condition of Punjab (Nandpuri *et al.*, 1975). The expression of heat tolerance in a genotype is influenced by several external environmental factors, therefore heat tolerant lines should be tested at various locations and environments (Villareal and Lai, 1979). Varieties HS-101, HS-102 had the ability to set fruit in April when temperature is about 35 to 38°C at Hisar (India). These varieties have performed well at Delhi conditions also under considerably high temperature at 38 - 40°C in the month of May. The ability to set fruits at high temperature in these genotypes varied depending on their physiological basis. Tolerance to heat may be expressed through heat avoidance and morphogenesis of flower parts, pollen fertility, rate of fertilization and fruit development (Kalloo, 1988). Meiosis before 7-8 days of anthesis is highly sensitive to high temperature. This leads to drop of buds due to formation of abscission layer in the pedicel. When flower fails to be pollinated and / or fertilized, it triggers the formations of abscission layer. The most noticeable effect of high temperature is the production of exserted styles which prevent pollination. In heat tolerant lines, stigma position is near the staminal cone and in heat sensitive cultivars, the style is elongated and exserted (Rana and Kalloo 1989 b). EC 130042, *L. cheesmanii* and EC-162935 setting fruits at high temperature exhibited stigma exsertion of less than 1 mm whereas other sensitive genotypes produced more than 1 mm stigma exsertion (Rana and Kalloo 1989 a,b). The most serious problem of high temperature effect is the reduced size of fruits. Generally there is fruit set in heat tolerant lines but development of such fruit is very slow and poor and as a result, the fruits remain smaller in size. At Delhi conditions, heat tolerant accessions EC-168070, 130053-1, 165393 were recorded to have larger fruit size as well.

When temperature falls below 0°C, tomato crop generally suffer chilling/frosting effect, under field conditions. In Hisar (India), *L. hirsutum* f. *glabratum* (Kalloo, 1988) adapted well under chilling/frosting conditions. *L. peruvianum* and *L. cheemanii* also sustain chilling temperature. At high

altitude of Ladakh (Himalayas), Early Lethbridge, Fireball and Early North (Canadian lines) were found suitable (Singh and Mital, 1966).

#### TOLERANCE / RESISTANCE TO OTHER BIOTIC / ABIOTIC FACTORS

Wild species show remarkable variation in their inherent adaptation to different kinds of stress environments and thus possess resistance to several abiotic factors. *L. pennellii* is a drought tolerant genotypes, *L. esculentum* var *cerasiforme* - tolerant to stress, *L. hirsutum* species are both tolerant and resistant to cold and drought. EC-130042, Sel-28, EC-65992 and *L. pimpinellifolium* (PI-205009) required longer number of days for expressing wilting, thus showing tolerance to drought conditions. If yield is the criterion; Sel-28, *L. cheesmanii*, K-14, EC-104395, *L. pimpinellifolium* (EC-65992) and *L. pimpinellifolium* - Pan American are the potential breeding material for drought resistance (Rana and Kalloo 1990). *L. pennellii*, *L. chilense* and a few accessions of *L. pimpinellifolium* have an inherent capacity to adapt under drought conditions. By utilizing these sources, there is possibility of developing salt and drought resistant commercial cultivars.

At several places, the problem of high temperature is linked with drought and humidity, therefore efforts should be made to develop heat + drought and heat + humidity resistant genotypes.

Wild species/ relatives of tomato have assumed considerable importance as these are known to possess high degree of resistance to various pests and diseases and thus could be utilized in breeding programmes. In order to explore the possibilities of utilization of these species as a source of disease resistance under hot summer season of Delhi, 88 germplasm collections of different wild species, viz., *L. pimpinellifolium* (30), *L. hirsutum* (15), *L. peruvianum* (20), *L. glandulosum* (2), *L. cheesmanii* (1) and progenies of *L. pimpinellifolium* x *L. esculentum* (20) were studied for field reaction to diseases (Table 2) Most of the *L. pimpinellifolium* lines were resistant to Fusarium wilt, fruit rot and early blight but didn't show any marked resistance to leaf curl. *L. hirsutum* and *L. peruvianum* showed high degree of resistance to leaf curl. *L. pimpinellifolium* x *L. esculentum* were resistant to Fusarium wilt and fruit rot. Some of the accessions showing resistance to more than one disease were as follows : *L. pimpinellifolium* (EC-65992, 65993, 86517, 86522 all from USA; - 7353 (Australia), - 121453 (Netherland) - resistant to wilt, fruit rot and early; *L. hirsutum* EC-486, -65999 and 127985 (USA) - resistant to leaf curl, Fusarium wilt and fruit rot; *L. peruvianum* (EC-2630, -65984, - 106293 (all from USA) and EC-86512 (from Japan ) - resistant to leaf curl, wilt and fruit rot; *L. pimpinellifolium* x *L. esculentum* (EC-66007, -86516, -99935, -106295 (all from USA) - resistant to Fusarium wilt and fruit rot (Bisht *et al.*, 1989).

### CONCLUSION

- a) Heat tolerant, moderately heat tolerant, drought tolerant lines identified.
- b) Better yield types, large fruited types, processing and suitability for long shelf life were also scored.
- c) Sources of resistance to Fusarium wilt, fruit rot/late blight, leaf curl and equally important fruit worm scored from hitherto unexploited *Lycopersicon* germplasm.
- d) Multiple resistance to wilt, fruit rot and early blight and other combinations and fruit attributes, firmness, smooth shape screened.
- e) Genetic manipulation to combine traits for tropical/sub-tropical adaptation - may lead to development of breeding lines carrying heat tolerance, resistance to diseases, improved fruit size, firmness and resistance to cracking which may be utilized in evolving better varieties.
- f) There is a need to screen germplasm even more for tolerance to high and low temperature, drought, excess moisture/flooding, poor soil fertility; to up grade absence of crack, reduce blotchy ripening, improved colour and long shelf life properties.

Stepwise approach to genetic improvement can be tried and emphasis should be given in bringing together heat tolerance and bacterial wilt resistance among the advanced breeding lines to grow a successful tomato crop in India. Broad-based genetic material are essential to meet a number of breeding objectives. Breeders can no longer be dependent on the basic stocks of cultivars which they inherited from their predecessors, and therefore it is obvious that much wider range of germplasm is required today. Also there is a need to develop cultivars which can set and produce large fruits at high temperature. Genetic manipulation to combine the requisite traits for tropical adaptation will lead to development of many breeding lines. Selection for high yield under non-stress and stress condition and incorporation of important heat tolerance (specific for hot dry conditions), drought resistance characteristics, tolerance to excess soil moisture or flooding, and even tolerance to poor soil fertility may be added into the physiological arsenal of the future tropical tomatoes. Breeding for heat tolerance is thus a challenge, and also an opportunity for breeders and heat tolerance researchers in developing countries. They can make advancement in this emerging field as they have at their disposal enormous variability adapted to specific situations of ecological stresses.

There will be a need to upgrade the quality of tomatoes also in visible parameters of acceptability such as increased longevity in transit and storage through better firmness and/or inherently long shelf life properties, absence of cracks, improved colour and reduced blotchy ripening etc.

### ACKNOWLEDGEMENTS

The authors wishes to express sincere gratitude to Dr. R.S. Rana, Director, National Bureau of Plant Genetic Resources, New Delhi 110 012 for facilities provided. Technical assistance by Sri Harinder Singh is also acknowledged.

### REFERENCES

- Bisht, I.S., Umesh Chandra and T.A. Thomas. 1989. Field reactions of wild tomato species to various diseases. *Veg. Sci.* 16(1): 104-106.
- Chaudhary, R.C. 1973. Summer tomatoes in north Indian plains: Problems of fruitlessness and parthenocarpy. *Bhartiya Krishi Anusandhan Patrika* 1: 39-44.
- Hanna, H.Y. and T.P. Hernandez 1982. Response of six tomato genotypes under summer and spring weather conditions in Louisiana. *Hort. Sci.* 17:758.
- Kaloo. 1988. Vegetable Breeding. Volume II. CRC press, Inc, Boca Raton, Florida. 213 pp.
- Kaloo, G. and M.K. Banerjee. 1990. Evaluation of tomato genotypes for heat tolerance. *Veg. Sci.* 17: (in press)
- Leeper, P. 1974. Saladette tomato : Basis for new industry. *Ann. Rep. Texas Agric. Exp. Stn.* 1974.
- N.B.P.G.R. 1991. Annual Report for 1990-91. National Bureau of Plant Genetic Resources, New Delhi, India, 172 p.
- Nandpuri, K.S., J.S. Kanwar, S. Singh and M.S. Saimbhi. 1975. Performance of tomato varieties under low and higher temperature conditions. *Haryana J. Hort. Sci.* 4 : 46-50.
- Rana, M.K. and G. Kaloo. 1989a. High temperature tolerance in tomato: evaluation of genotypes. *Veg. Sci.* 16: 156-167.
- Rana, M.K. and G. Kaloo. 1989b. High temperature tolerance in tomato: flower and pollen studies. *In: 12th Eucarpia Congress. Vortrage Pflanzenzucht.* 15: 23.
- Singh, H.B. and S.P. Mital. 1966. New Bred varieties fetch better return. *Indian Hort.* 10:11-16.
- Thomas, T.A. and Umesh Chandra. 1989a. Genetic resources of tomato in India, their build-up, evaluation, maintenance and utilization. p. 22-27. *In: S.K. Green, T.D. Griggs and B.T. Mclean (eds.). Tomato and Pepper production in the Tropics, AVRDC, Shanhu, Tainan, Taiwan.*
- Thomas, T.A. and Umesh Chandra, 1989b. Genetic resources of tomato and their evaluation. *Indian J. Plant Genet. Resources* 2(1): 15-31.
- Thomas, T.A. and Umesh Chandra. 1991. Evaluation and identification of donor germplasm in tomato adaptable to Indian climates. Paper presented in Golden Jubilee Symp. on Genetic Research and Education : Current trends and the next fifty years, organized by Indian Society of Genetics and Plant Breeding, New Delhi from Feb 12-15; Vol I (Abstr): 71-72.
- Umesh Chandra and T.A. Thomas. 1993. Sources of tomato germplasm adaptable to the hot summer season in India. p 501-502. *In: C.George Kuo (Ed.) Adaptation of Food crops*

to temperature and water stress. Asian Vegetable Research and Development Center, Shanhua, Tainan, Taiwan.

Villareal, R.L. and S.H. Lai. 1979. Development of heat tolerant tomato varieties in the tropics. Proc. 1st Intl. Symp. Trop. Tomato. Asian Vegetable Research and Development Center, Tainan, Taiwan. 188.

Villareal, R.L., S.H. Lai and S.H. Wong. 1978. Screening for heat tolerance in the genus *Lycopersicon*. *Hort. Sci.* 13: 479.