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Genetic Resources in Tomato and Their Evaluation

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Tomato is one of the most popular and widely grown vegetable in the world ranking second in importance to potato in many countries. The centre of origin of genus Lycopersicon *is a narrow belt of South-American west coast and the Andes. The greatest variability occurs outside this area in Mexico, Central America and coastal Peru. Because of its climatic tolerance, tomato has been proved to be one of the most versatile cultivated plants. The erstwhile Plant Introduction Division (IARI) under the leadership of late Dr. H. B. Singh, started genetic resources activities long back and over the years, the NBPGR has assembled a total of 2, 659 collections in tomato from diverse agro-climatic zones of the world (from over 40 countries) and from within India. These were tested/evaluated in phased manner but during past two years, data were recorded systematically on 39 different agro-botanical and economic characters. Donor types were indentified for different traits. High yielding, paste types, heat tolerant lines, and collections suitable for good/excellent transportation were sorted out for their utilization as direct selections or exploitation as parental material in hybridization programme.*

The tomato is relatively a recent addition to the world's important food crops. Within the past century, it has become one of the most popular and widely consumed vegetable crops with an annual world's production of *ca* 50 million metric tons. In India, tomato can be grown nearly throughout the year since favourable climatic conditions are available in one part of the country or the other. It is cultivated in *ca* 80,000 hectares in different parts and is well adapted to all the regions. On an average, a normal crop of tomato yields 16,000 to 24,000 kg per hectare. Considerable variability has been generated through introductions from several countries of the world from time to time as well as through breeding efforts in the past three decades. Germplasm collections have been further augmented by Germplasm Exchange division of the NBPGR. The present paper highlights the efforts in evaluation and identification of world genetic resources in tomato.

MATERIALS AND METHODS

The NBPGR and erstwhile Plant Introduction Division of the Indian Agricultural Research Institute through introductions from various parts of the world assembled 2,659 germplasm accessions from over 40 countries (Table 1). In

TABLE 1. TOMATO GERMPLASM IN INDIA

Sources of germplasm collection/introduction	Accessions
(i) Exotic germplasm	2,229
USA, Philippines, UK, Canada, Australia, Protugal, Italy, Argentina, Cyprus, Mauririus, Israel, Netherlands, Nepal, Tanzania, Turkey, Japan, Iraq, Chile, Yugoslavia, Denmark, Switzerland, China, Trinidad, S. Africa, Czechoslovakia, Ghana, Germany, Hungary, Taiwan, Poland, Iraq, Bulgaria, South America, Columbia, Hongkong, Spain, United Arab Republic, Burma, Nigeria, Newzealand and Brazil.	
(ii) Indigenous germplasm	430
West Bengal, Tamil Nadu, Madhya Pradesh, Maharashtra, Uttar Pradesh, Himachal Pradesh, Karnataka, Bihar, Jammu & Kashmir, Andhra Pradesh, Haryana, Gujarat, Mizoram, Sikkim and Manipur.	
Total Germplasm Assembled	2,659

India, several pockets in Madhya Pradesh, Maharashtra, Uttar Pradesh, Bihar, West Bengal, Andhra Pradesh, Himachal Pradesh, Karnataka, Tamil Nadu, Jammu & Kashmir, Mizoram, Sikkim and Manipur were explored and fairly rich variability was collected. The entire tomato germplasm is maintained at New Delhi centre of NBPGR. The germplasm collections were grown in augmented design at NBPGR Experimental Farm, Issapur and were evaluated systematically over the years for 39 different agro-botanical and economic characters. Several wild species, introduced in the last decade or so are also being maintained such as *L. pimpinellifolium, L. hirsutum, L. peruvianum, L. glandulosum, L. cheesmanii, L. chilense, L. esculentum* var *cerasiforme* and *L. pissisi*.

RESULTS AND DISCUSSION

The collections varied in plant height (25-167 cm), number of branches per plant (3-19), number of clusters per plant (4-201), number of flowers per cluster (2-26), number of fruits per cluster (1-22), number of fruits per plant (8-790 including wild material) and average weight of 10 marketable fruits (30-167 g). Several high yielding, paste types, heat tolerant lines and collections with excellent transportation quality (Table 2) were identified for their utilisation either as direct selection or exploitation as parental material in hybridisation programme (Thomas and Umesh Chandra, 1988). Table 3 lists such genetic resources identified for different agro-ecological zones of India.

The screening of tomato germplasm has helped in the identification of many donors of which only a few have been used in the breeding programme. Several cultivars particularly from exotic sources such as Sioux (ex USA), Best of All,

TABLE 2. DONOR TYPES IDENTIFIED FOR BREEDERS USE

Traits	Donor germplasm
High yield	EC Numbers : 1127, 1153, 3069, 4708, 6049, 6053, 7291, 9016, 9149, 11238, 10309, 27412, 16920, 17960, 27918, 42662, 35395, 54645, 66504, 101652, 110176, 125754, 126776, 128524, 126776, 128524, 128693, 128969, 129600, 129699—p^2, 129081, 129353, 129354, 129081, 129353, 129757, 129171—p^{1-1}, 130035, 130163, 130163—p^{2-1}, 141854-1, 145515, 161251, and DM 83-12, DM 83-21 and Bulgarian.
Heat tolerant	EC Numbers : 41824, 7764, 9149, 9149, 35211, 54315-1, 122963, 129666—p^1, 32611, 126955, 159979, 141832, 14073—p^2, 27936, 27929, 128964, 2599, 35220, 27251, 37264, 43225, 54027, 61691, 103595, 111085, 1139, 41025; PI Numbers : 126453, 126923, 130/47, MH/81-3, 78/81-13, IC 23571.
Processing type	Bulgarian, EC 942, 1193, 2790, 480, 1132, 1154, 8822, 4229/p^2, 54627, 35461, 52062, 89258, 110578, 161252, 160187, 145623, 141814, Ont 717; IC 15212; M 28/81; 12 etc.
Suitable for transportation	EC 4229/p^2, 19/18-6, 7167, 7352, 8822, 100845, 110268, 99184, DM Sel 3-1; EC 130049, 168541, 171072.
Resistant to Fusarium wilt and fruit rot	EC Numbers 160195, 1149, 1184, 1151, 1136, 6589, 26108, 35401, 16163, 122527, 21626, 103598, 116874, 117008, 115947, 37192, 117671, 117103, 119116, 5962, 4764, 54716, 455, 119187, 35488/p^{2-1}, 110116, 109181-2. 54716, 54628A, 54628B, 50366-1-1-1. 104162/p^2—1, 106261, 66504, 11662, 12659, 12957, 129380 and EC 128769.
Resistant to fruit borer	EC Numbers : 262, 2669, 490, 491, 6200, 7764, 6987, 16787-1, 23528, 110264, 101552, 1747, 57289, 65077, 59621, 129354, 11520-1, 124406, 129599, 129597, 129698, 129699/p^{2-1}, 129469, 128016, 119791, 43264, 66005, 65984, 2630, 121443, 86526, 20685, 121451, 2792, 85622, 160191, 21318, 161254, 9227, 18223, 118266. 119121; IC 59067; 51/81-3, 14/81-6, 78/81-8, 100/81—A, M 3/81-3, DM/81-14, DM—3, DM 83-7, 51/81-2, 28/81-3, 95/81-2, 51/81-3 and 14/81-6.

EC Numbers represent exotic collections obtained from other countries and maintained at the National Bureau of Plant Genetics, New Delhi-110012, India.

Fireball (ex Canada), Rutgers, Early Lethbridge, King Humbert, Roma (ex USA), la Bonita (ex USA), Dwarf Money Maker (ex Israel), Pan America, Early Chatham have been found to perform well. Other varieties like Marglobe, Best of All, Italian Red Pear and Roma performed well in different parts of India.

Selections have also played important role in tomato improvement in India. Improved Meeruti was evolved at the IARI through selection from an Indian cultivar from Meerut in Uttar Pradesh (Singh and Sikka, 1955), Other selected indigenous material are Meeruti, HS-101, HS-102, KS-1, KS-2, S-11, CO-1 and

TABLE 3. IMPORTANT VARIETIES IDENTIFIED IN TOMATO FOR DIFFERENT AGRO-ECOLOGICAL ZONES IN INDIA

Variety, source and year of identification	Suitable zones*	Varietal characteristics
1	2	3
Pusa Ruby, IARI/NBPGR, (1975)	II, IV, VI VII and VIII	Plant height 80-85 cm, indeterminate growth habit, spreading, less branched and hardy. Fruits flat, round, small to medium, uniform deep red, slightly lobed (4-5 locules). slightly acidic, 25-30 fruits per plant, early variety, maturity 60-65 days, suitable for autumn, winter & spring summer seasons in plains. Good for juice & Ketchup. It is an old variety derived from the cross Improved Meeruti × Sioux.
HS-101, Hisar (1975)	I, II, IV, VI and VIII	Plant height 50 cm, dwarf multi-branched sturdy and determinate in growth habit. Fruits bearing in cluster of 2-3, round small to medium in size, 3-4 locules, Fruits ripe uniformely, 40-50 fruits per plant. Suitable for winter senson.
S-12 Ludhiana (1975)	I, II, IV VII and VIII	Plants are dwarf, bushy, vigourous, fruits are medium sized, compressed round. Uniformly coloured, red at maturity, juicy highly acidic. Average yield 175-230q/ha. Suitable for marketing, fresh for table.
Sel 120 IARI/NBPGR (1975)	I, IV, VI, VII and VIII	Semi-determinate, spreading type, foliage dark green good covarage, fruits attractive, round to flattish round, medium to large in size, smooth, uniform, red in colour, less acidic & less seeded. Resistant to nematodes. suitable for summer & winter.
T-1 Pantnagar (1975)	I, II, IV, VII and VIII	Plant height 100-120 cm, tall, erect and indeterminate in growth habit, foliage, green in colour, Fruits round, slightly, pointed at the stigmatic end, 4-5 locules, 4-5 fruits per plant, non-cracking, red on ripening, susceptible to TMV.
Sweet-72 Gwalior (1975)	I, II, IV and VII	Plants determinate type, fruit flattish round green stem end, slightly furrowed. Uniform maturity. Heavy yielder.
Puss Early Dwarf, NBPGR (1975)	I, II, IV and VIII	Plant typical dwarf 50-55 cm in height with determinate growth habit. Fruit set closely roundish slightly flattish, medium large, uniform red, ribbed, obscurs furrow, 5-6 locules 30-40 fruits

Contd..

TABLE 3. (*Continued*)

1	2	3
		per plant. Maturity in 55-60 days after transplanting, suitable for *rabi* season in plains and March in hills.
Sioux, IARI (1977)	II, IV, VI and VII	Plants with indeterminate growth habit, fruits round, smooth, medium to large, attractive red on ripening, less seeded, Maturity 60-70 days after transplating Suitable for summer & Spring in plains & hills both.
Pusa Gaurav (Sel-152) IARI (1983)	I, II, IV, VI, VII and VIII	Determinate growth habit, leaves with light green foliage, fruits yellow, smooth, oblong, two locules, uniform ripening, matutity 80-85 days after sowing, Excellent for processing and suitable for long transportation.
Punjab Chhuhara, Ludhiana (1981)	I, II, IV, VI, VII and VIII	Plants dwarf, bushy and determinate growth habit with dense and luxurient foliage, Fruits are medium sized, pear shaped, firm, fleshy, usually bilocular, less seedy, less sour, thick walled, uniformly coloured, red at maturity, ratain marketable quality for a week after harvesting under ordinary condition during summer. Most suitable for long transportation. Average yield 300-320 q/ha.
MS-22 Kalianpur (1985)	I, II, IV and VI	Plants determinate, foliage light green, fruit flattish round, slightly furrowed. Moderate yield. Stem end and leaves are slightly rolly, number of locules 4-5.
Pant Bahar (AC-238) Pantnagar (1985)	I, II IV and V	Plant height 90 cm, bushy indeterminate in growth habit and branched. Light green foliage, stem relatively thin, leaflets small in size. First ripening in 78 days. Fruits flattish round, medium in size, 5-6 locules, slightly ridged, red on maturity. Resistant of Verticillium wilt and Fusarium wilt under field conditions. Good storage and processing qualities.

*Zones :

I = Humid Western Himalayan Region
II = Humid Bengal-Assam Basin
III = Humid Eastern Himalayan Zone and Bay Islands
IV = Sub-humid Satluj-Ganga Alluiral Plains
V = Sub-humid to Humid Eastern and South-Western Uplands
VI = Arid Western Plains
VII = Semi-arid Lava Plateau and Central Highlands.
VIII = Humid to semi-arid Western Ghate and Karnataka Plateau.

CO-2 (a pure line selection from Kalianpur cultivar) for Tamil Nadu. Selection-120 was selected from breeding material (Helani numbers) received from Dr. Gilbert of Hawaii. This cultivar has been found to be promising for nematode resistance and is a high yielder with large, round and attractive fruits. Hybridization programme utilising exotic cultivars as one of the parents, has been successful in evolving cultivars like Pusa Ruby (Sioux × Improved Meeruti), Pusa Early Dwaf (Improved Meeruti × Red Cloud), Pusa Red Plum (*L. esculentum* × *L. pimpinellifolium*) — the material of *S. pimpinellifolium* was received from Dr. B. B. Mundkar, Punjab Chhuhara (Israel Introduction EC 55055 × Punjab Tropic) and Sweet 72 (Pusa Red Plum × Sioux). Mutation breeding was also exploited in developing cultivars like S-12 and CO-3. Heterosis has been exploited in F_1 hybrids in tomato to a great extent in the last 50 years in developed countries like USA, Japan, etc. In India, heterosis in tomato resulted in an increased yield of 20 to 50 per cent (Pal and Singh, 1943; Chaudhary *et al.*, 1965). Two very promising combinations were Red Jacket × Meeruti using closed anther mutant (Mital *et al.*, 1962) and Pusa Ruby × Best of All (Chaudhary *et al.*, 1965). It has been reported that superior hybrid yield was obtained in a cross between Pusa Early Dwarf and Selection 120, when selection 120 was used as pollen parent.

Studies on inter-specific hybridisation in tomato (*L. asculentum* × *L. pimpinelifolium*) in India resulted in Pusa Red Plum-an early, cultivar rich in Vitamin C and sugar (Pal and Singh, 1943) from interspecific hybridisation between *L. esculentum* and *L. pimpinellifolium*. Similarly in USA, Porte and Waker (1943) evolved Pan America cultivar resistant to Fusarium wilt.

Wild relatives have been evaluated for high tolerance to poor soils, the ability to withstand droughts, to resist insects and to be tolerant to excessive moisture. Without question, the greatest contribution to tomato improvement has been through the development of cultivars resistant to common pathogens. The wealth of genetic diversity from germplasm holdings in Indian gene bank has yielded a few sources of resistance. Sel 673 and EC 37192 have been found to be highly resistant to Fusarium wilt whereas Dwarf Money Maker, Marglobe are moderately resistant to this disease. The cultivated tomato suffers from numerous viral diseases also. Chaudhary *et al.*, (1973) have reported that breeding lines B 2247 and Holmes PI showed high degree of resistance to TMV. Among allied species, *L. peruvianum* and *L. hirsutum* were characterised as resistant to TMV. *L. peruvianum*, *L. hirsutum* and *L. esculentum* lines, P-13, XXXII—354—A—Silvestra, B 2247 and Sel. 498 and two lines each of *L. peruvianum* (Lp-6, Lp-8) and *L. chilense* were identified as resistant to leaf curl virus. In addition, *L. peruvianum* has been reported as highly resistant to *Meloidogyne incognita* but susceptible to *M. arenaria* and *M. javanica*. Resistant cultivars available with Southern Tomato Exchange Programme are Anahu, Florida, Hawaii Cross, Hawaii 55, Nemered, Atkinson and VHF-8. In India, Singh and Chaudhary (1972) reported Nematex as immune, Atkinson, VHF 8, 65N-215-1 and 65N-255-1 as resistant and Selection 120 as highly tolerant to root-knot nematode.

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