Unlocking the Genetic Treasures of Tomato Wild Relatives: A Path to Sustainable Agriculture

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ABSTRACT

Tomato wild relatives hold invaluable genetic traits for disease resistance, stress tolerance, and improved yield. Exploring these untapped resources offers sustainable solutions to modern agricultural challenges. By integrating their genes into cultivated varieties, breeders can enhance crop resilience, ensuring food security and environmental sustainability in the face of climate change.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most significant and extensively cultivated vegetable crops in tropical and subtropical regions. It belongs to the Solanaceae family and originates from the western coastal areas of South America, particularly Peru and Ecuador (Rick, 1969). The tomato was introduced to Europe in the 16th century by Spanish explorers. Today, it is grown globally, with numerous cultivars and varieties suited to various climates and growing conditions (Smith, A. F., 2012). Although it was once classified as *Lycopersicum esculentum* Mill. due to its distinct morphology compared to other Solanum species, synteny mapping led to its reclassification as *Solanum lycopersicum* L. (Peralta *et al*., 2006). While primarily an annual, self-pollinating plant, the tomato can also exhibit perennial or semi-perennial traits under certain environmental conditions (Geisenberg and Stewart, 1986).

Centre of domestication

The western regions of South America, particularly the coastal areas of present-day Ecuador and northern Peru, are considered the center of domestication for wild tomato species (Darwin *et al*., 2003). These areas are rich in biodiversity and host various wild tomato species closely related to the cultivated tomato (*Solanum lycopersicum*). Both Mexico and the Andes are recognized as centers of diversity and domestication for *S. lycopersicum*, with Mexico showcasing the greatest morphological variation in tomatoes (Rick, 1979; Jenkins, 1948).

Taxonomy and Distribution

Tomatoes possess a somatic chromosome number of 24 and a haploid number of 12 (Luckwill, 1943). In somatic tissues during mitotic metaphase, tomato chromosomes are relatively small compared to other angiosperms, measuring approximately 1.5 to 3 µm in length. These chromosomes exhibit considerable variation in their morphological characteristics, including mating systems, habitat preferences, trichome densities and types, as well as levels of resistance to pests and diseases. These traits are essential for breeding programs and improving agricultural practices.

In addition to the cultivated tomato (*S. lycopersicum*), there are 17 recognized wild species, including *S. cheesmaniae*, *S. galapagense*, *S. chilense*, *S. chmielewskii*, *S. habrochaites*, *S. neorickii*, *S. pennellii*, *S. arcanum*, *S. corneliomulleri*, *S. huaylasense*, *S. peruvianum*, *S. pimpinellifolium*, *S. sitiens*, *S. juglandifolium*, *S. lycopersicoides*, and *S. ochranthum* (Peralta and Spooner, 2005). These wild relatives and hybrid forms are a rich source of genetic diversity, making them invaluable for crop improvement and conservation efforts. They provide essential genetic material for developing more resilient and productive tomato varieties (Causse *et al*., 2016).

Table 1: Distribution and Habitat of tomato wild relatives (Luckwill, 1943; Rick, 1986; Taylor, 1986; Peralta 2008)

Species Name	Lycopersicon equivalent	Distribution
Solanum arcanum Peralta	Part of *L peruvianum* (L.) Miller	Northern Peru. Coastal and inland Andean valleys, on dry rocky slopes; 100 to 2500 m.
Solanum cheesmaniae (L. Riley) Fosberg	*Lycopersicon cheesmaniae* L. Riley	Endemic to the Galápagos Islands (Ecuador);1350 m.
Solanum chilense (Dunal) Reiche	*Lycopersicon chilense* Dunal	Southern Peru to northern Chile. On western slopes of the Andes, hyper-arid rocky plains, dry river beds, and coastal deserts; 3000 m.
Solanum chmeilewskii (C. M. Rick, Kesicki, Fobes and M. Holle) D.M. Spooner, G.J. Anderson and R.K. Jansen	*Lycopersicon chmeilewskii* C.M. Rick, Kesicki, Fobes and M. Holle	Southern Peru to northern Bolivia (Sorata). In high dry Andean valleys; 2300-3000m.
Solanum corneliomuelleri J.F. Macbr. (1 geographic race: Misti nr. Arequipa)	Part of *Lycopersicon peruvianum* (L.) Miller; also known as *L. glandulosum* C.F. Müll.	Central to southern Peru. On western slopes of the Andes;1000-3000 m.
Solanum galapagense S.C. Darwin and Peralta	*Solanum galapagense* S.C. Darwin and Peralta	Endemic to the Galápagos Islands, particularly the western and southern islands, mostly occurring on coastal lava and on volcanic slopes; 650 to 1,500m
Solanum habrochaites S. Knapp and D.M Spooner	*Lycopersicon hirsutum* Dunal	Central Ecuador to Central Peru. In premontane forests to dry forests on the western slopes of the Andes, occasionally in lomas formations in northern Peru; 400-3600 m.
Solanum huaylasense Peralta and S. Knapp	Part of *Lycopersicon peruvianum* (L.) Miller	Northern Peru (Department of Ancash). On the rocky slopes along rivers; 1700-3000.
Solanum juglandifolium Dunal	*Lycopersicon ochranthum* (Dunal) J.M.H. Shaw	Northeastern Colombia to southern Ecuador; 1200-3100m.
Solanum lycopersicum L.	*Lycopersicon esculentum* Miller	Apparently native to Peru.

Solanum lycopersicoides Dunal	*Lycopersicon lycopersicoides* (Dunal in DC.) A. Child ex J.M.H. Shaw	Southern Peru to northern Chile on the western slopes of the Andes on dry rocky hillsides; 2800-3700 m.
Solanum neorickii D.M. Spooner, G.J. Anderson and R.K. Jansen	*Lycopersicon parviflorum* C. M. Rick, Kesicki, Fobes and M. Holle	Southern Ecuador to southern Peru. In dry Andean valleys, often growing over rocky banks and roadsides; 1950-3000 m,
Solanum ochranthum Dunal	*Lycopersicon juglandifolium* (Dunal) J.M.H. Shaw	Central Colombia to southern Peru, in montane forests and riparian sites; 1400-3660 m
Solanum pennellii Correll	*Lycopersicon pennellii* (Correll) D'Arcy	Northern Peru to northern Chile, in dry rocky hillsides and sandy areas; 2850 m.
Solanum peruvianum L.	*Lycopersicon peruvianum* (L.) Miller	Central Peru to northern Chile. In lomas formations and occasionally in coastal deserts; 600 m,
Solanum pimpinellifolium L.	*Lycopersicon pimpinellifolium* (L.) Miller	Apparently native to coastal areas from central Ecuador to southern Peru, although populations are found in Vallenar, Chile; 0- 500 m. Grows in humid places and on the edges of cultivated fields throughout its native range and has apparently escaped from cultivation in the Galápagos.
Solanum sitiens I.M. Johnst.	*Lycopersicon sitiens* (I.M. Johnst.) J.M.H. Shaw	Northern Chile, western Andean slopes on rocky hillsides and dry quebradas; 2350-3500 m

Floral biology

Tomato wild relatives exhibit three different mating systems. Some species, like *S. lycopersicum, S. galapagense, S. cheesmaniae, S. pimpinellifolium, and S. neorickii*, are self-pollinating (autogamous) and self-compatible, meaning they can fertilize themselves. Others, such as *S. chmielewskii*, are facultatively self-compatible, allowing for self-pollination but having floral traits that promote cross-pollination. Lastly, some species are allogamous and self-incompatible, rejecting their own pollen to encourage cross-pollination. Examples include *S. arcanum*, *S. habrochaites*, and *S. pennellii*, though some populations may show partial self-compatibility (Peralta and Spooner, 2005).

CONCLUSION

The wild relatives of tomatoes hold immense potential for advancing modern agriculture. Their rich genetic diversity provides crucial traits such as disease resistance, environmental adaptability, and enhanced nutritional qualities that are vital for developing stronger, more resilient tomato varieties. As global challenges like climate change and food security continue to grow, these "hidden gems" of the tomato family offer invaluable resources for breeding programs and sustainable farming practices. By tapping into the genetic wealth of these wild species, we can safeguard the future of tomato cultivation and ensure a stable food supply for generations to come.

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