Conservation of tomato species germplasm

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The tomato is a classic example of a cultivated plant that has been markedly improved by hybridization with primitive cultivars and related wild species. During the past 40 years such crosses have transferred genes for many useful traits. Resistance to Fusarium and Verticillium wilts and to nematodes was bred from these sources. High soluble solids content of fruits and resistance to other diseases are currently being transferred to improved cultivars.

South American origin

The nine known tomato (*Lycopersicon*) species are native to northwestern South America. Most of these species are restricted to a narrow zone between the Andean crest and the Pacific Coast; furthermore, within this zone in Peru and Chile they are found only in river valleys and areas that receive appreciable moisture from seasonal fog layers. Several species occupy territory east of the Continental Divide, and one comes only from the Galapagos Islands.

The wild form of the cultivated tomato (*L. esculentum* var. *cerasiforme*) and primitive cultivars of the same species are known from most of the territory occupied by the strictly wild species. Within the entire region of the tomato's origin, the various races of these species exist in many different habitats which vary from desert-like conditions to those of excessive moisture, and from the hot tropics to much cooler conditions up to the 3,000 meter elevation.

This great variety of habitats is matched by astonishing variability between and within species. In *L. peruvianum*, for example, many distinct races can be identified. Even within a population each plant may differ from all the others in readily observable traits.

In recent years, improved domestic and imported cultivars have completely replaced native, primitive types in coastal Peru and other areas. Thus, the primitive cultivars, save a few obtained before the transition and maintained in U.S. collections, are extinct. Encroaching agricultural, industrial, and residential activities that obliterate native habitats of the wild species have taken their toll. For example, certain stands of *L. hirsutum* and *L. peruvianum* known 20 to 25 years ago no longer exist.

Foresight in collecting

It is evident that a sound and permanent germplasm program is essential to preserve resources continually needed in California tomato production. For thirty years the Department of Vegetable Crops on the Davis campus of the University of California has maintained a collection of tomato species germplasm as part of its program in tomato breeding and genetics. This Tomato Genetics Stock Center, partially supported by the National Science Foundation, makes germplasm samples available to interested investigators. The Center periodically issues lists of accessions for which sufficient viable seeds are stocked. The latest list in Tomato Genetics Cooperative Report No. 27 itemizes 397 accessions.

The broad objective is to accession a representative range of variation of each species. Often it is prudent to acquire every item that can be obtained. Sources are other collections, seed firms and other private organizations, professional and amateur plant collectors, or plant-hunting expeditions. We conducted three major expeditions to the tomato's native haunts in 1948-49, 1956-57, and 1970-71, and three shorter trips in 1963, 1974, and 1976. Seed collecting was supplemented by notetaking on many aspects of population biology and features of the habitats; preparation of herbarium specimens; photographing pertinent materials; and observations of pollination systems and other aspects of the environment.

Evaluation

The first evaluation of an accession should take place in the native habitat, where one can observe the variability and other features of the wild population. The absence of insect and disease ravages may yield clues as to the presence of hereditary resistances. The ability of the plants to set fruit under such stress conditions as high or low temperatures suggests further avenues of utilization. Survival of wild plants in very wet, dry, or saline situations can allude to the presence of desirable traits for certain breeding objectives.

The salt tolerance of some *L. cheesmanii* accessions exemplifies a type of stress resistance, first detected in the native habitat. We were astonished at the thriftiness of several plant colonies growing along the northwest shores of Isla Isabela in the Galapagos Islands in 1971. Only 5 meters distant from and 2 meters above the tide line, the plants were exposed to high salt concentrations from ocean spray and from diffusion through the sandy soil. Seeds were collected and planted at Davis for observation.

It was demonstrated that: (1) these accessions can tolerate (but at a reduced growth rate) up to 100 percent sea water in their rooting medium—far more than other tomatoes can endure, and (2) the ability to withstand such salinity is based on tolerance of tissues of the plant, not on any barrier to salt uptake or movement within the plant.

Another example of the value of field observation is found in the natural drought resistance of *Solanum pennellii*—a species that readily hybridizes with the cultivated tomato. Despite a greatly reduced root system, it grows only in very dry situations in the quebradas of western Peru. It receives virtually no rainfall, but condensation from frequent mists and fogs probably supplies needed moisture. Research on the nature of this drought resistance and the breeding of it into tomato cultivars is in progress.

Clearly most information on the value of plant accessions must come from studies of experimental plantings in which other economically useful traits can be observed. Resistance to pests is found by growing accessions in the presence of particular insects and pathogens. High soluble solids content of fruit was discovered in our plantings of *L. chmielewskii* and proved to be more than twice as high as that in domesticated species, but utterly


Lycopersicon cheesmanii tomato growing on beach rocks on Isla Isabela, Gelapagos, provides a potential source for salt resistance.


Cultivated tomatoes have been improved by genes transferred from primitive cultivars and related wild species.

useless in the tiny, green-ripe, vile-flavored wild fruits. But crossing with a standard cultivar, backcrossing to the latter for five generations, and then pedigree selection produced large, red-fruited tomatoes with nearly 50 percent increased solids content. The development of commercial varieties for California production is in progress.

Frequently a given character cannot be evaluated adequately in the accession itself because crossbreeding with the cultigen may result in modified expression or even loss of expression. Further, entirely new, unsuspected characters can appear after crossbreeding. A broad attack is needed, involving large-scale backcrossing from the wild to the cultivated parents.

Variability

Another important part of evaluation is the measurement of variability in accessions. If plants are inbred and genetically very uniform, evaluation is relatively simple. But the greater the degree of outcrossing, the more variable the accession and the larger the sample size must be for adequate testing of its merits.

Traditionally, variability has been measured in morphological characters, but recently biochemical methods have been developed. For example, separation and identification of isozymes permits simple and vastly more accurate estimates of genetic variability within populations and at other levels. By this method, we have learned that self-pollination is predominant in *L. cheesmanii* and *L. parviflorum*, whereas mating systems differ greatly in *L. pimpinellifolium* from one part of its range to another.

Proper evaluation also includes observation of chromosome number, morphology, and pairing behavior, and tests of compatibilities in crosses between species. Such tests have revealed that all of the wild tomato species can be hybridized with *L. esculentum* cultivars, albeit with varying degrees of difficulty. Transfer of desired genes from the wild parent is therefore possible.

Maintenance of germplasm

To maintain viability of the original accession, seed stocks must be stored under optimum conditions and replenished whenever the seeds begin to lose germination capacity or supplies become diminished. Maintenance of integrity depends on the method of renewal. The naturally inbred, highly uniform accessions can be increased satisfactorily by merely allowing a few plants of each to automatically self-pollinate. At the other extreme are such species as *L. chilense* and *L. peruvianum* that cannot self-pollinate and depend on insect cross-pollination. We isolate such accessions sufficiently to prevent cross-contamination with other accessions and intercross plants on a sufficient scale from a wide genetic base to preserve a maximum of natural variability. The problem is exacerbated if the accession requires a short day for flowering, which necessitates use of controlled environments. Intermediate situations are encountered in self-fertile accessions that are naturally subject to varying degrees of cross-pollination.

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The wild tomato *Solanum pennellii*, growing among the rocks and cacti of west central Peru, is a potential source of drought resistance for California varieties.