POTATO GERMPLASM COLLECTING EXPEDITION TO CHILE, 1989, AND UTILITY OF THE CHILEAN SPECIES

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Abstract

A joint Chilean, United States potato (*Solanum* sect. *Petota*) germplasm collecting expedition was conducted in Chile between January 21-March 30, 1989. The trip resulted in collections of *Solanum brevidens* (50 accessions), *S. etuberosum* (28 accessions), *S. maglia* (3 accessions) and indigenous primitive landraces of *S. tuberosum* (24 accessions). Comments are presented on the habitats, distribution, and potential and realized breeding value of these species.

Introduction

The latest taxonomic interpretation of *Solanum* sect. *Petota* (26) includes 232 species, including 22 subspecies and varieties, distributed from the southwestern United States to southern Chile. Eleven of these taxa are naturally occurring in Chile (series *Cuneolata* Hawkes: *S. infundibuliforme* Phil.; ser. *Etuberosa* Juz.: *S. brevidens* Phil. var. *brevidens*, var. *glabrescens* [Poepp. ex. Schltd.] Hawkes, *S. etuberosum* Lindl., *S. fernandezianum* Phil., *S. palustre*, Poepp. ex. Schltd., *S. subandinum* Meigen; ser. *Juglandifolia* (Rydb.) Hawkes: *S. lycopersicoides* Dun., *S. sitiens* Johnston; ser. *Maglia* Bitt.: *S. maglia* Schltd.; ser. *Tuberosa*: *S. tuberosum* L.). *Solanum etuberosum*, *S. fernandezianum*, *S. palustre*, *S. subandinum*, *S. sitiens*, and *S. tuberosum* are endemic to Chile. All of the above are $2n=2x=24$, except *S. maglia* with $2n=2x=24$ and $2n=3x=36$, and *S. tuberosum* with $2n=2x=24$, $2n=3x=36$ and $2n=4x=48$ (fide 6, 7, 8). Distributions of the above are presented in (14, 36). Ongoing taxonomic studies by Spooner and Contreras indicate that *S. brevidens* var. *glabrescens*, *S. palustre*, and *S. subandinum* may be synonymous with other species; these data will be presented in a separate publication.

Germplasm collections of these species were initiated in 1956 by investigators at the Universidad Austral de Chile (13). These collections, and remnants of earlier collections formerly made by the Chilean Department of Agriculture (18, p. 10) currently are maintained as both true seed and

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clonal accessions at the Universidad Austral de Chile. The latest statistics of the germplasm holdings there are presented in (14). The low numbers of accessions of these species at the Inter-Regional Potato Introduction Project (IR-1) (25) led to the USDA-funded expedition reported here.

Contreras and Rick (14, 43) searched extensively and intensively in the northern half of Chile for *S. infundibuliforme*, *S. lycopersicoides*, and *S. sitiens*, with relatively less collecting for *S. brevidens*, *S. etuberosum*, and *S. maglia*, distributed in the southern half of Chile (14). *Solanum infundibuliforme* has not been recollected in Chile. The goals were for IR-1 to obtain duplicates of *S. lycopersicoides* and *S. sitiens* from Contreras or Rick and for Spooner and Contreras to collect the above listed southern species in addition to devoting a small amount of time to collect *S. tuberosum* in Chiloé Island. Ochoa (37) indicated that indigenous populations of this species have been almost completely replaced by modern European varieties. Diverse landrace populations of this species form the bulk of the potato germplasm holdings in Valdivia, and can be obtained there.

Results

Collections are detailed in Fig. 1, Tab. 1. Detailed itinerary and collection data can be obtained from the authors. Collecting for *S. maglia* commenced along the Pacific Coast northwest of Santiago, followed by collections southward in the Andes (for *S. etuberosum*, *S. brevidens*) to Chiloé Island (for *S. tuberosum*) until February 28. Spooner then returned northward to fill in gaps in the initial collecting.

Solanum maglia. *Solanum maglia* presents interesting phylogenetic and distributional problems in *Solanum* sect. *Petota*. The species is unique in sect. *Petota* in possessing a loose, barrel-shaped anther column with anthers and filaments not well differentiated from each other. These features led Hawkes (26) to place this species in the monotypic series *Maglia*. The only non-Chilean collection is from a single locality on the lower slopes of the Andes in Argentina, Prov. Mendoza, Quebrada de Alvarado (app. 34°S), ca. 200 km away from the closest population in Chile. Hawkes and Hjerting (27) hypothesize that *S. maglia* evolved from *S. kurtzianum* Bitt. et Wittm., an Argentinian species, with later migration of *S. maglia* to Chile. All Chilean populations of *S. maglia* are distributed along coastal Chile approximately from latitudes 30°S-33°30'S, and from sea level to 700 m elevation (14, 18). Most populations are sterile triploids, $2n=3x=36$, presumably autotriploids (27, 39) reproducing entirely by tubers, but one diploid population is known from each of Argentina and Chile.

Three collections were made of *S. maglia*, all from slopes facing the Pacific Ocean, from latitudes 32°33'S-32°55'S, at altitudes 20-40 m. The coast is mostly very dry here, but with isolated, interspersed moist habitats where this species can be found. Associated species include *Carpobrotus aequilaterus*

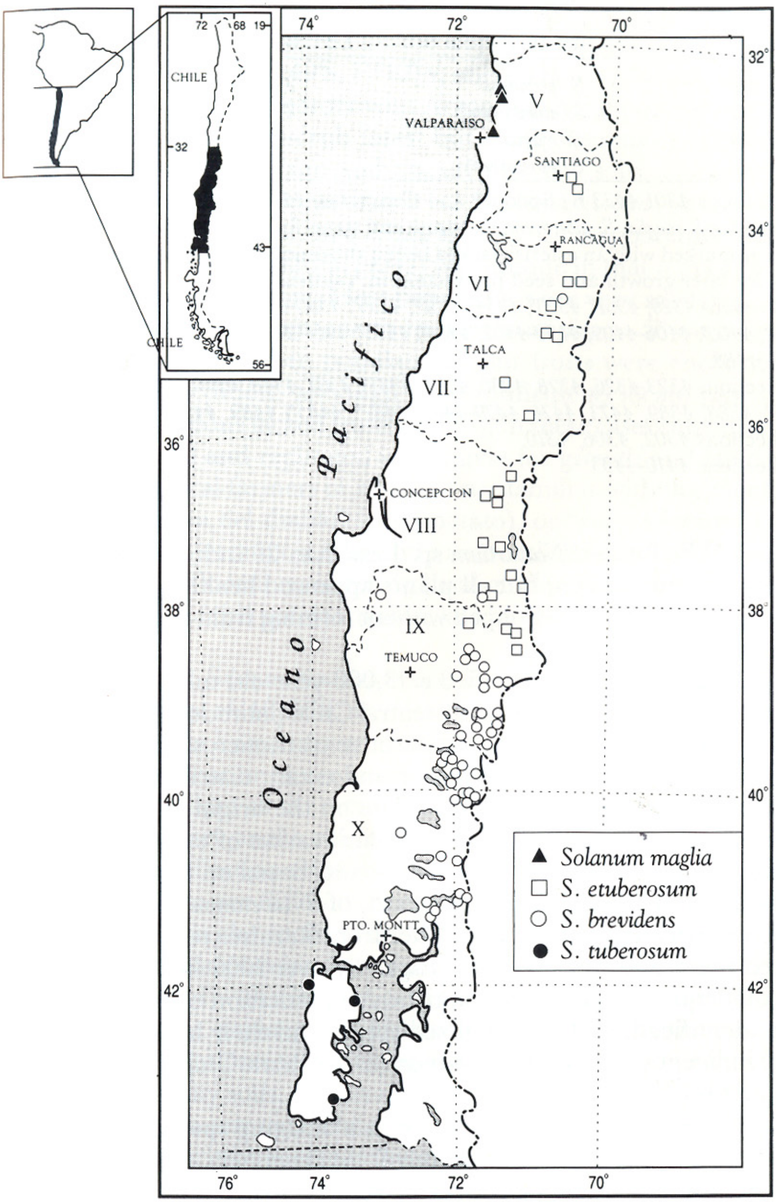

FIG. 1. Collection sites of the 1989 Potato Germplasm Collecting Expedition.[1]

TABLE 1.—*Summary of collections of* Solanum *sect.* Petota, *Chile, 1989.*[1]

		No. of Collections		
Series	*Species*	*Seeds*	*Tubers, Rhizomes and Stems*[2]	*Total*
Etuberosa	*S. brevidens*[3]	39	11	50
	S. etuberosum[4]	22	5	28
Maglia	*S. maglia*[5]	0	3	3
Tuberosa	*S. tuberosum*[6]	0	24	24

[1] Collections *4301-4433* by Spooner and Contreras; *4450-4491* by Spooner.

[2] Tubers for *S. maglia*, *S. tuberosum*; rhizomes and stems for *S. brevidens* and *S. etuberosum*. Collections marked with an asterisk lacked fruits; rhizomes and stems of these were brought back for later growth and seed production in Valdivia.

[3] Collections 4329, 4351*, 4353*, 4354, 4355*, 4356*, 4390-4393, 4395-4398, 4399*, 4400-4402, 4403*, 4405*, 4406-4409, 4450-4452, 4454*, 4455*, 4456-4469, 4470*, 4471, 4472, 4484, 4486*, 4487, 4488.

[4] Collections 4323-4326, 4328, 4330, 4331, 4333*, 4337, 4348, 4340, 4341, 4349, 4350, 4352, 4387*, 4388, 4389, 4473, 4474, 4479-4481, 4482*, 4485*, 4489, 4490, 4491*.

[5] Collections *4302, 4306, 4310.*

[6] Collections *4410-4433.*

(Haw.) N.E. Br. and *Nasturtium* sp. Less than 20 individuals were located in any one population, but all plants appeared healthy. All flowered prolifically, but the flowers dropped without forming fruit, suggesting that these were sterile triploids.

Ugent *et al.* (47), identified a 13,000-year-old tuber from the Monte Verde archaeological site in southcentral Chile (latitude 41°30'S) as *S. maglia*, basing their conclusions on comparative ultramicroscopy and optical interference patterns of starch grains and extant distributions of *S. maglia.* They extended these data to speculate on the origin of *S. tuberosum* from *S. maglia* in southern Chile. Their identification of extant populations of *S. maglia* from Chiloé Island, however, was based on a probable misidentification in the field, at Chiloé Island, of *S. tuberosum* as *S. maglia*, and no voucher specimens were made (letter from Ramírez to Spooner). This distorted the southern range of *S. maglia* by over 1000 km. The starch data are inadequate, as they lack statistical presentation of comparative data. The identification of the fossilized tuber, and their hypothesis of a separate, indigenous origin of *S. tuberosum* in southern Chile, therefore, is open to question (26).

Solanum maglia has been utilized as a bridging species for the incorporation of late blight resistance from *S. demissum* (44). Contreras (14) summarizes resistance of this species to aphids, *Verticillium* wilt, viruses A, X and Y, and to wart. *Solanum maglia* has been incorporated into seven North American varieties released between 1956-1985, as well as one European variety (40).

Solanum etuberosum. We collected *S. etuberosum* from latitudes 33°30'S-38°20'S, at altitudes of 500-2245 m. Searches north of this range along Rt. 60 to Mendoza, Argentina (approx. latitude 32°50'S), failed to locate the species. All populations occurred on the slopes of the andean cordillera. One population (*4490*, at 37°49'S, 71°10'W, at Hito Paso de Copahue) grows within 3 km by air from the border with Argentina. Most populations were located in areas of low, dry scrub forest but along streams or in the mist of waterfalls, always in full sun and usually in rocky soils. Common associated species include *Alstroemeria ligtu* L., *Escallonia revoluta* (Ruiz et Pav.) Pers., *Fuchsia magellanica* Lam., and *Urtica dioica* L. One apparently healthy flowering and fruiting population (*4341*) was unique in that it grew in volcanic cinders away from water. Most populations are very scattered, with population sizes varying from one to hundreds of plants. Flowering and fruiting times varied between populations, but fruits were encountered throughout the expedition, although more difficult to locate past mid-March. Some collections lacked fruits (Tab. 1); in these cases rhizomes and stems were collected and replanted in Valdivia for growth and later seed production. Most local farmers or ranchers are familiar with this plant, locally known as "papa del diablo" (devil potato), or "papa silvestre" (wild potato). Collections were most efficiently accomplished on horseback, after asking advice on locations or hiring local guides. Contreras (14) summarizes resistances of this species to cold, late blight, the peach aphid, and PLRV.

Solanum brevidens. Solanum brevidens was collected from latitudes 34°45'S-41°52'S, at altitudes of 40-1170 m. Collection *4329*, made at 34°45'S, 70°34'W, extends the known range of this species by more than 300 km. This species occurs near or on the lower slopes of the andean cordillera and on the coastal cordillera to the west (18, 36). Habitats are more used for agriculture and forestry on the coastal cordillera, and populations are more difficult to locate; collection *4484* was the only one we located there. The habitats of *S. brevidens* are different from those of *S. etuberosum*. Generally, *S. brevidens* is found in the more mesic habitats to the south of the range of *S. etuberosum*, growing under or in the general area of *Nothofagus* forests, commonly associated with *Chusquea quila* Kunth, *Fuchsia magellanica* Lam., *Gunnera* sp., *Ribes* spp., *rosa canina* L., *Rubus ulmifolius* Schott, *Scirpus* spp., and *Urtica dioica* L. Populations occur in open sun or partial shade, usually in deep organic or mucky soils, always in moist habitats. Unlike *S. etuberosum*, populations are more common and relatively easy to locate. Flowering and fruiting times also varied between populations but commenced later in the season than *S. etuberosum*, with best collecting of fruits between February 15 and March 15. For those collections lacking fruits (Table 1) rhizomes and stems were collected and replanted in Valdivia for growth and later seed production. The common names and local knowledge of localities of this species are the same as for *S. etuberosum*. Its relatively more common occurrence and growth in more accessible areas make most collections accessible by jeep and foot travel. Contreras (14) summarizes resistances of this species to cold, late blight, leaf hoppers and viruses A, Y and PLRV.

Solanum brevidens and *S. etuberosum* differ morphologically from other members of *Solanum* sect. *Petota* only by the absence of tubers, possession of thickened rhizomes, and low pedicel articulation. All species in ser. *Etuberosa* exhibit crossing barriers to the tuber-bearing members of *Solanum* sect. *Petota*, but successful interspecific hybrids were accomplished between *S. etuberosum* and *S. pinnatisectum* Dun., a diploid Mexican tuber-bearing species (30). These diploid hybrids had greatly reduced meiotic pairing and complete sterility (41), but the fertility was restored by allopolyploid production (29). Although morphologically similar, the genomes of *S. brevidens* and *S. etuberosum* (as well as *S. fernandezianum*) exhibit interspecific translocations (42). Despite crossing barriers, sexual gene transfer between both *S. brevidens* and *S. etuberosum* and cultivated tuber-bearing species has been accomplished with the aid of bridging species (10, 11, 19), and between *S. brevidens* and cultivated tuber-bearing species by somatic fusion hybrids (1, 4, 20). These sexual and somatic techniques have allowed for the transfer of extreme resistances to potato leaf roll virus and potato virus Y (5, 21, 28, 32), *Erwinia* soft rot (2), and may be able to incorporate the frost resistance present in *S. brevidens* and *S. etuberosum* (45).

Solanum tuberosum. Twenty-four tuber collections were made of landrace populations of *S. tuberosum* on Chiloé Island, as well as on Isla Metalqui and Isla Caucahue, just off the northwest and northeast shore of Chiloé Island, respectively. The western two-thirds of Chiloé Island is covered with dense forests and is uninhabited, while the eastern one-third is devoted to agriculture, with potato the staple crop. European introductions and new cultivars predominate (*e.g.*, Desireé, Pimpernel, Yagana, Gineke, Industrie, Isola, Ackersegen), but many farms maintain small plots of "papas antiguas" (ancient potatoes) or "papas chilotas" (Chiloé potatoes), which they grow for the enjoyment of their diverse shapes, colors, or tastes. There is much inter-farm exchange of these cultivars, and they are widespread and common throughout Chiloé Island. Most of the primitive cultivars are virus-infected. At one collection site, the backyard garden of Clarisa Colivoro in the town of Yaldad, 14 different cultivars were collected, including the diploid "Mantequilla," that Ochoa (38) indicates is an introduction of *Solanum goniocalyx* Juz. et Buk. from central Peru.

The place of origin of the original European potato has been the subject of great controversy since Juzepczuk and Bukasov (33) first suggested Chile. They based this conclusion on the long daylength adaptation and the morphological similarities of European and indigenous Chilean potatoes. Salaman (46) challenged this view, suggesting an Andean origin, basing his arguments on the comparative morphology of early potato introductions as seen from early illustrations and herbarium specimens, as well as examinations of early transportation routes. This Andean introduction hypothesis is today supported by (6, 7, 8, 24, 26, 31) and others.

Also controversial is the place of origin of the Chilean cultivars, with competing hypotheses arguing for indigenous origins (*e.g.*, 9, 47) or transport from the Andes (perhaps after hybridizations in the Andes) with later differentiation in Chile (*e.g.*, 6, 7, 8, 24, 26, 46). Because of the confusion regarding the taxonomic identity of all of these clones, the collections from this expedition are identified as *S. tuberosum* without reference to subspecies, and could possibly even be regarded as different cultivated species following the taxonomic concept of Hawkes (26).

Additionally, much controversy surrounds the breeding utility of the Chilean landraces, although their previous use is well-established. The Chilean clones Daber, Rough Purple Chile, and Villaroela are present in the majority of modern cultivars (Plaisted and Hoopes, 1989). This controversy began when McKee (26) indicated that 92% of the 208 Chilean samples of *S. tuberosum* at the Commonwealth Potato Collection in England were infected with virus PVA, PVS, PVX, or PVY. It was intensified when Glendinning (22) indicated that in addition to virus infection, the Chilean introductions exhibited low flowering, low fertility, and late maturity, but these problems could have been a result of the virus infection. He suggested that they were a highly inbred subset of the variability from ssp. *andigena*. Glendinning (23) suggested that a much better source of genes for disease resistance and heterotic effects was a group of *S. tuberosum* ssp. *andigena* selected for long daylength adaptation and other quality traits, "Neo-Tuberosum."

This negative view of Chilean landraces recently has been challenged by investigators at the Universidad Austral de Chile in Valdivia. Contreras *et al.* (15), present evidence indicating profuse flowering and high fertility of the Chilean clones, countering Glendinning's observations to the contrary (22). Macias-M. *et al.* (34), demonstrate much electrophoretic diversity within identical morphotypes of the Chilean accessions, but no comparative data exist for ssp. *andigena*. Resistance has been shown to PVX (16), PVY (17), and *Erwinia* soft rot (12). Some unimproved Chilean cultivars, even some virus-infected ones, have yields equal to modern cultivars (3). Contreras (14) summarizes other data on fertility and resistance in the Chilean landraces. Because breeding with these extant Chilean landraces has not yet progressed to the point of a variety release, and because the materials have not yet been tested outside of southern Chile, the relative advantages of these clones to ssp. *andigena*, both in southern Chile and elsewhere, is unknown.

A detailed itinerary and complete collection data are on file at the Universidad Austral de Chile in Valdivia, at IR-1, and at the USDA, ARS

Germplasm Introduction and Evaluation Laboratory in Beltsville, Maryland. The germplasm will be increased at IR-1 and will be freely available internationally.

Summary

New germplasm collections were made of *S. brevidens* (50 accessions), *S. etuberosum* (28 accessions), *S. maglia* (3 accessions), and *S. tuberosum* ssp. *tuberosum* (24 accessions). The preexisting collections of the Universidad Austral de Chile genebank, combined with the collections from this trip, make Chile one of the best-collected countries with regard to its native germplasm. Deficits yet exist, however, for collections of *S. tuberosum* from the Chonos and Guaitecas Archipelagos south of Chiloé Island and of *S. fernandezianum* from Masatierra Island off the coast of Chile, and future expeditions to Chile should concentrate on these species.

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