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ECO GEOGRAPHY AND BREEDING POTENTIAL OF THE WILD PERUVIAN TUBER-BEARING SPECIES OF *SOLANUM*

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About 225 wild tuber-bearing species of *Solanum* occur on the American continent. Seventy-five percent of these are distributed in South America, with the largest concentration (approximately 100 species) occurring in Peru.

Located on the western side of South America, Peru has five main regions: the Pacific Ocean Territory, the Coast, the Sierra, the *Ceja de Selva*, and the *Selva*. Wild potatoes are found only along the Coast, the Sierra, and the *Ceja de Selva*.

The Coast (Fig. 1), a vast desert territory 2500 km long and 150 km wide, varies in elevation from sea level to 1000 m. The central and southern part of this region is usually covered with low clouds from April or May until October or November. When these clouds touch the mountains to the east, they produce a very fine condensation or mist called *garúa*. This mist gives rise to a special ephemeral plant formation called the *loma*, which is notably lacking in species diversity. Within this coastal fog zone, the precipitation is extremely low, ranging from 4 to 80 mm of rainfall per year. Temperatures range from 13 to 23°C, and the humidity varies from 65 to 95 percent. During the winter season, some tuber-bearing species of *Solanum* occur in the *lomas* formation, including *S. immite*, *S. medians*, *S. mochiquense*, *S. chancayense*, *S. neo-weberbaueri* and *S. wittmackii*. Not only are these species remarkable for their drought tolerance, but some are also quite resistant to viruses, fungi and bacteria. *Solanum immite*, for example, the first tuber-bearing species described for Peru by Dunal in 1852, is resistant to the *spindle tuber* viroid (PSTVd) and to the fungal wilt caused by a *Verticillium* species.

Solanum medians, a coastal mountain species, has perhaps the widest distribution in the *loma* formations of the Peruvian coast. It is found from the Lomas de Manchay (350 m asl.) near La Molina, Lima (12°05' S and 76°56' W) all along the southern Peruvian coast to the Lomas de Ilo (400 m asl.) and the Lomas de Sama (550 m asl.) in the departments of Moquegua and Tacna (or approximately 17°48' S and 70°30' W). At Manchay-La Molina, the average annual precipitation is only 18 mm, while at Sama Grande it is 40 mm. The monthly median temperature for both places is 24°C and the minimum is nearly 13.5°C.

Solanum medians represents a valuable source of genes for potatoes breeding programs. It is resistant to the attack of several potato viruses, including potato virus X (PVX), leaf roll (PLRV), potato viruses S (PVS) and M (PVM) and the potato spindle tuber viroid (PSTVd). It is also resistant to the tuber canker fungus, *Synchytrium endobioticum*; to the potato ring rot disease caused by the bacterium, *Corynebacterium*; the cyst nematode *Globodera rostochiensis*; and the tuber moth, *Phthorimaea operculella*.

The most northern *loma* formation along the Peruvian coast is found at Cerro Campana (400 m asl.) in the vicinity of Trujillo (08°05' S and 79°06' W). Here, thrives *Solanum mochiquense*, a species resistant to the potato black leg bacterium, *Erwinia carotovora*; the fungal organism, *Synchytrium endobioticum*; potato viruses PVS, and PVM; and, the nematode *Meloidogyne*.

The Sierra divides the Coast from the Selva

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Fig. 1. Coast near the Cerro Campana, complex of *Lomas* formation in the vicinities of Trujillo, 400 m asl., habitat of *S. mochiquense*.



Fig. 2. *Puna* of Marcapomacocha, 4500 m asl., near Lima, habitat of *S. acaule*.

and consists of a wide chain of mountains replete with deep valleys and high grassland areas or *punas* (Fig. 2). It is not unusual for the mountain crests in this region to reach elevations ranging between 5000 and 6700 m. The majority of the tuber-bearing species of *Solanum* of this region, however, are found in the lower valleys or mountain quebradas at altitudes between 2500 and 3400 m. Here, the precipitation varies between 500 and 600 mm during the long growing season (September to April), an amount which is considerably more than along the coast. Temperatures vary from a maximum of 20°C to a minimum of 9°C, and the humidity is approximately 85%

Habitats of the type described above are found in the vicinity of Mount Chungarrán (2800 m asl.) in the low *sierras* of Contumazá and San Benito in the department of Cajamarca, northern Peru. Here, a number of potentially valuable diploid species ($2n = 24$) occur. These include *S. chiquidenum*, which has major genes (R) of resistance against the late blight fungus *Phytophthora infestans*; *S. contumazaense*, a species covered with fine, short, soft erect hairs that could find use in potato breeding studies aimed at the control of aphids that transmit some kinds of viruses; and, the exotic species, *S. guzmanguense*, which has among its several extraordinary characteristics a tall growth habit, simple leaf shape and a large white rotate corolla.

Another exotic species is *S. anamatophilum*, which is known from a dry canyon of the Santa River (2700 m asl.) in the Department of Ancash in northern Peru. As this species displays an unusual amount of tolerance to drought, it could be valuable in potato breeding programs.

Another species of potential economic value is *S. ambosinum*, which grows in the Valley of Ambo (2800 m asl.) near Huánuco, in north-central Peru (10°08' S and 76°12' W). This species, which is resistant to PLRV and to the attack of *Erwinia carotovora*, is interesting from evolutionary point of view since it is morphologically very similar to the cultivated *S. tuberosum* subsp. *andigena* in growth habit, leaf shape, large rotate corolla and the large size of its tubers.

The Sacred Valley of Pisacc-Urubamba (Fig. 3), near Pisacc (13°26' S and 71°57' W), at 2600 m asl., in southern Peru, is the habitat of another rare species, *S. lignicaule*. This creamy-white flowered and velvety leaved species has an extremely glutinous odor that is repellent to insects and aphids, a characteristic that could be useful in plant breeding.

The high Sierra, between 3500 and 4500 m asl., is called *jalca* (Fig. 4) or *páramo* in northern Peru and *Puna* in the central and southern regions. A typical example of *jalca* is at Porcón (07°03' S and 78°38' W), which is situated at an



Fig. 3. Sacred Valley of Urubamba-Pisacc, near Cusco, 2600 m asl., habitat of *S. lignicaule*.



Fig. 4. Jalca formation, near Porcón, 3600 m asl., dept. Cajamarca, habitat of *S. albicans* and *S. jalcae*.

altitude of 3600 m near Cajamarca. This area receives 944 mm of precipitation between September and April. Temperatures range from 14° to 4°C, and the humidity varies from 37 to 93 percent. This cool, moist region is the type locality of *S. albicans*, one of only three hexaploid ($2n = 72$) wild species known for Peru. Besides being frost tolerant, this species is also highly resistant to viruses PLRV and PVX and to the viroid PSTVd. It is also highly resistant to the bacterium *Corynebacterium sepedonicum*; fungi such as *Synchytrium endobioticum* and *Verticillium* sp.; and the nematodes *Meloidogyne* and *Globodera*.

Two other *jalca* species from northern Peru are *S. jalcae*, a highly frost resistant species, and *S. chomatophilum*, which shows a high degree of tolerance to the Colorado beetle or *Leptinotarsa decemlineata*, the most devastating pest of the potato crop in United States. One of the more promising Peruvian tuber-bearing species from the standpoint of the genetic improvement of the cultivated potato, *S. chomatophilum* is also resistant to *Phytophthora infestans*, frost, and more than a half dozen different types of viruses. It also shows resistance to the three most dangerous potato bacterial diseases, these causing black leg, ring rot and bacterial wilt.

The high punas of central and southern Peru (Fig 4) occur at elevations between 3500 and 4500 m. These range from latitude 10°40' S to 15°52' S, and at a longitude of approximately 70°02' W. In these cool, moist regions, the precipitation varies from 550 to 650 mm during the growing season. Temperatures range from 16° to 2°C, and the humidity varies between 78 and 52 percent. Occurring in this habitat are the tetraploid *S. acaule* ($2n = 48$) and the diploids *S. bukasovii* and *S. leptophyes*. All three species



Fig. 5. Pajonal of *Stipa ichu*, in Puna formation, asociated with *S. acaule* and *S. bukasovii*, between Juliaca and Puno, 4000 m asl.

are resistant to *Globodera pallida* and *Globodera rostochiensis*. However, according to screening trials made at the International Potato Center in Lima, Peru, as well as in the United States and Europe, the most valuable of these three species for plant breeding purposes is *S. acaule*. Among its other desirable qualities, this species has been found to be resistant to viruses PVX, PVY, PLRV, PVS, PVT, TRV, APLV and APMV, as well as PSTVd. It has also been found to be resistant to the disease-causing fungi *Alternaria solani*, *Synchytrium endobioticum*, *Fusarium* and *Verticillium*; the bacteria *C. sepedonicum*, *E. carotovora*, and *Pseudomonas solanacearum*; and insect pests such as *Premnotrypes suturicallus*, *Macrosiphum euphorbiae* and *Phthorimaea operculella*.

Finally, the formation known as *Ceja de Selva* (or *Selva Alta*) is found on the eastern slopes of the Andean cordillera between 1500 and 3600 m. This sparsely to densely forested region is different from the *Sierra* in that the climate varies depending upon altitude from humid and subtropical to tropical. Its large river system,



Fig. 6. *Ceja de Selva* formation: Urubamba Canyon, 2400 m asl., near Machu Pikchu, Cusco, habitat of *S. urubambae* and *S. santolallae*.

which carries a great volume of water, forms a part of the Amazon Basin.

One example of the *Ceja de Selva* (Fig. 5) formation occurs at an elevation of 2400 m in the Urubamba Canyon near Machu Pikchu in southern Peru (13°09' S and 72°31' W). In this region, the average rainfall during the growing season (August to April) surpasses 2000 mm. Temperatures range from a maximum of 9° to 21.5°C, and the humidity stands at about 90 percent. This moist canyon is the habitat of *S. urubambae*, *S. santolallae* and *S. buesii*.

Another area where the *Ceja de Montaña* or *Ceja de Selva* formation occurs is at 900 m altitude in the Chanchamayo Valley near San Ramón (11°03' S and 75°18' W) in the Department of Junín in central Peru. However, temperatures are higher in this region, ranging from 15 to 32°C. Occurring at this densely forested locality is the species *S. laxissimum*, a plant which produces a stem nearly 3 m tall. The tubers of this unusually robust wild species weigh up to ½ kg each, this in contrast to the great majority of the tuber-bearing species which usually yield tubers weighing no more than 5 to 20 g. This species, along with the three others mentioned above (*S. urubambae*, *S. santolallae* and *S. buesii*) are resistant to bacterial wilt. Moreover, all four could be useful in the breeding of new commercial varieties for the warm and humid tropics.

In conclusion, it needs to be emphasized here

that the wild tuber-bearing species of *Solanum* that occur along the Coast, Sierra and *Ceja de Selva* regions of Peru show resistance to pests and diseases under a wide scope of climatic conditions. The germplasm collections of these species that are now currently available at CIP could provide the plant breeder of the future with the raw genetic materials that are needed for the improvement of the cultivated potato.

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