CIP CIRCULAR

INTERNATIONAL POTATO CENTER ISSN 0256-8632 Vol. 16, No. 3, September 1988

Archaeological Remains of Potato and Sweet Potato in Peru

Donald Ugent and Linda W. Peterson[1]

Fig. 1. Ruins of La Centinela, situated on the south-central coast of Peru. This large administrative and ritual center served as the capital of the Chincha nation until it was conquered by an invading army of Inca warriors in the year A.D. 1476. Although this site remained populated for another 56 years, it was destroyed eventually by the Spanish conquistadores. Today, an abundance of cultural artifacts, animal bones, and plant remains lie exposed in middens left uncovered by desert sands.

The discovery of archaeological remains of the actual tubers and roots of potato and sweet potato in Peru has contributed greatly to our present-day knowledge of the ancient distribution of these two crops and their use as primary food sources by Peru's early coastal inhabitants. Preserved remains unearthed from the refuse heaps, or middens, located in the vicinity of ancient ruins (Fig. 1) as well as samples recovered from ancient tombs and burial sites have yielded archaeological records that point to the early development of agriculture and civilization in the New World. Tombs and burial sites have also proved to be an important source of material in the form of cloth tapestries that occasionally bear woven images of potato or sweet potato and of ceramic vessels representing these two crop plants as well as others such as achira, maize, peanut, and squash (Sauer, 1951). The artistic representation of food plants in the woven materials and pottery of the ancient Peruvians, which are artifacts of many types and of different cultural periods, show us that a crop was in the process of development long before its

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CIP CIRCULAR

Published quarterly in English, French, Spanish, and Chinese by the International Potato Center (CIP) Apartado 5969 Lima, Peru

Linda W. Peterson, Editor

CIP is a nonprofit, autonomous, scientific institution established by agreement with the Government of Peru for developing and disseminating knowledge for greater use of the potato and other tuber and root crops as basic foods. CIP is supported by the Consultative Group on International Agricultural Research (CGIAR), which is an informal association of governments, private foundations, and international and regional organizations, dedicated to supporting a system of agricultural research centers and programs around the world. The information and conclusions reported in this publication do not necessarily reflect those of any of the aforementioned agencies, foundations, or governments.

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first appearance in the archaeological record.

From these lines of evidence, we can determine that potato and sweet potato were grown together more or less co-extensively in the oases of Peru's isolated coastal river valleys. The area of cultivation extended as far north as the Casma Valley in the Department of Ancash, to the more southerly coastal city of Pisco, in the Department of Ica, with the sweet potato having an additional range of cultivation southeast to the area of Nazca (Fig. 2).

The oldest known samples of potato and sweet potato, dating to the Neolithic Period (and perhaps to the end of the last Ice Age, or 8000 B.C. according to Engel), were discovered in caverns at Chilca Canyon, in the south-central area of coastal Peru (Engel, 1970). These highland caves, known locally as "Tres Ventanas," are located 65 km southeast of Lima at an altitude of 2800 meters. Archaeological remains of other Peruvian crop plants such as the common bean, lima bean, pepper, oca, and olluco—also known to be of great antiquity—were discovered in middens of the Pleistocene age (8000 B.C.) at the Guitarrero Cave in the highland areas of the Department of Ancash (Kaplan, 1980; Smith, 1980).

From the above studies, we learn that man had already domesticated a number of plant species by the end of the last Ice Age, including tuber and root crops such as potato and sweet potato. Today, the preserved remains of these two food sources found in the Chilca caves furnish us with clues as to the importance of these crops in the Peruvian coastal area as early as 10,000 years ago, at a time when climatic and environmental conditions worldwide were very different from what they are today.

Climatic and Geological Setting

Just prior to the time when the Chilca Canyon crops were being grown, vast ice sheets covered large tracts of North America and northern Europe. The central and southern parts of South

Fig. 2. Distribution of prehistoric potato (●) and sweet potato (□) remains on the coast of Peru.

America, including the Andean highlands, were glaciated, with ice extending down the mountains of Peru to an altitude of approximately 3000 meters (Simpson, 1975; Vuilleumier, 1971).

Most of the areas where potatoes are grown today in the Peruvian highlands were not available for potato cultivation during the close of the Pleistocene glacial epoch, or the last Ice Age—the end of which corresponds to the era of incipient agriculture in the New World, 8000-6000 B.C. These areas were either covered with a thick mantle of snow and ice or were in the process of being gradually warmed and exposed. However, the maritime zone and the middle and lower western slopes of the Central Andes were probably available for human occupation since preglacial times.

During the Late Pleistocene, the shoreline of Peru was situated further to the west than it is today. In this respect, it is interesting to note that the growth of the glacial ice sheets across the northern and southern polar regions of the earth consumed so much ocean water by evaporation that sea levels throughout the world dropped by nearly 100 meters (Richardson, 1973, 1981). In Peru, the lowering of the ocean level had the effect of exposing portions of the continental shelf, thus the southern coastal beaches extended some 10 km further to the west and the northern coastal beaches more than 100 km west of the present-day shoreline. Therefore, archaeological sites found today on the coast were located much further inland during glacial times than they appear to be in the present. Moreover, sites that were situated directly along the coast in the Late Pleistocene are now submerged under more than 100 meters of the Pacific Ocean.

Another change that affected the coastal area during the Late Pleistocene was a change in the coastal climate, caused partly by the lowering of the ocean level and partly by a shift westward in the normal directional flow of the Humboldt Current, which today normally flows north and south parallel to the coasts of Chile and Peru. With the outward movement of this cold current, an increase in precipitation occurred on the western edges of the South American continent. This change in climate appeared to be more radical in the northern part of Peru's coastal area than in the south.

The vegetation covering the northern coast of Peru during immediate post-glacial times was probably similar to that which occurs today along the south-central coastline of Ecuador (Ugent et al., 1984, 1986). Toward the end of the Pleistocene (ca. 8000 B.C.), much of the Peruvian coastal area was covered by a vast grassy savanna with intermittent groups of woody areas. Fossils of extinct mastodons, horses, and camelids have been found in this region, indicating that the savanna once provided abundant forage for herds of large animals.

The Pre-Agricultural Age

By the time of the melting of the great ice sheets, man was already widely settled along the western coast of South America. According to Lanning (1970), there are about 18 archaeological Pleistocene sites known from the northern and western coasts of South America. These are distributed from Venezuela to southern Chile. In Peru, Pleistocene sites occur at Ancón (8500 B.C.; Lanning, 1965), Cerro Chivateros in the Chillón Valley (12,000 B.C.; Lanning and Patterson, 1967), Chilca Canyon (8800 B.C.; Engel, 1970), Flea Cave in the Department of Ayacucho (12,200 B.C.; MacNeish, 1970), and Guitarrero Cave in the Department of Ancash (10,500 B.C.; Lynch, 1980).

Two sites that predate the last glacial advance are also known for South America. One of these, Monte Verde in south-central Chile, dates to 31,000 B.C. (Dillehay and Collins, 1988); while the other, Pedra Furada in northeastern Brazil, goes back to 30,000 B.C. (Guidon and Delibrias, 1986). The radiographic evidence obtained recently for Toca da Esperança, another site with several caves in northeastern Brazil (Lumley et al., 1988), suggests that man may have populated that part of South America at some period between 204,000 and 295,000 years ago (Middle Pleistocene).

The dwellers of the Pleistocene coastal-savanna lands in Peru probably made use of the several wild relatives of the potato and sweet potato that are still known from the moister river valleys scattered along the coast. Like their fellow landsmen at Monte Verde, Chile, who were known to be harvesting and using wild coastal potatoes (*Solanum maglia*) as early as 13,000 years ago (Ugent et al., 1987), the people of the Peruvian savanna lands were primarily plant gatherers, hunters, and fishermen.

The campsites of pre-agricultural man may have been the areas where the process of plant domestication first began (Ugent, 1970). Through the introduction of two or more related wild species of a genus to the fertile kitchen middens of a campsite, a series of hybrid wild forms may have eventually arose, which were later gathered up by man and taken from one campsite to another; or these forms may have migrated naturally along a network of trails connecting the different sites. When it came time for the deliberate planting of crops, these weedy, ubiquitous, "camp follower" races were ready for their final stages of domestication.

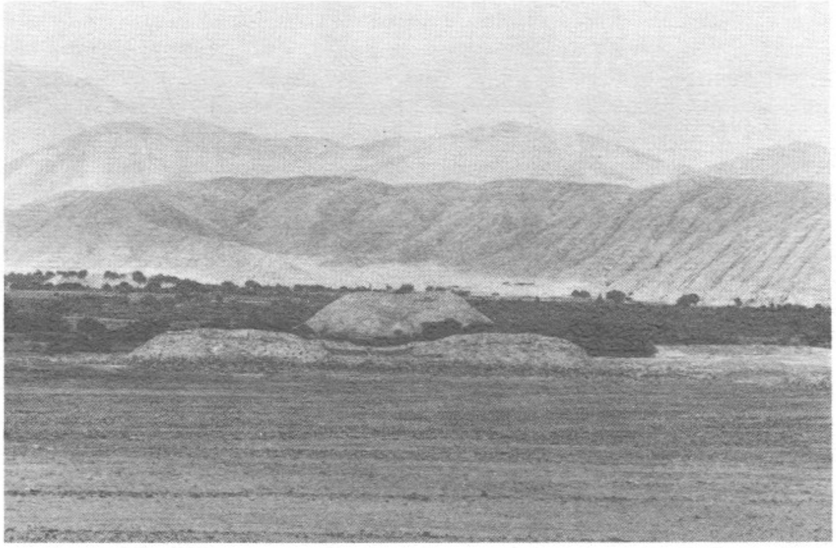
Era of Incipient Agriculture

During the early post-glacial period, patterns of human subsistence were changing from economies based on hunting and fishing to those based on plant and animal domestication. A rapid growth in human population along the western coastline of South America, coupled with the gradually increasing aridity of the climate and a decline in the availability of natural resources, may have all had their effect in persuading a hungry populace to engage in the deliberate planting of food crops. These developments led ultimately to the construction of large urban centers along the north-central Peruvian coast and the founding of the formal rudiments of art, religion, and science. Similar happenings were also occurring at this time in the Old World, most notably in Mesopotamia, Eygpt, the Indus Valley, and China. These advancements, however, never occurred among the primitive, nomadic tribes of the equatorial rainforests of the world, including the Amazon region of South America. In this region, disease, infanticide, and warfare were the factors most responsible for keeping human populations in check, and since wild plant foods and game were normally available, there was no special need for tribal members to take on the extra work involved in the deliberate planting, weeding, harvesting, and storage of vegetable crops.

With the dawn of agriculture in South America, the wild species of potato and sweet potato that were formerly gathered from the upper river valleys and ancient savanna lands of coastal Peru were now being grown purposefully by early man in the first primitive small fields and garden plots. This development probably occurred over a wide area of the western coast of South America. Thus, the domestication of potato and sweet potato over the course of time may have involved somewhat different but related wild ancestral stocks, which would have been cultivated at different coastal localities and elevations, and at somewhat different prehistoric times.

Later, as the altiplano ice sheets and mountain glaciers retreated, the prototypes of our modern Andean potatoes were introduced into the newly developed, highland agricultural areas, where, as a result of their subsequent intermixing, intercrossing, and polyploidization, these prototypes merged at several chromosomal levels to form our present-day cultigens. On the other hand, the early coastal cultivars of the sweet potato found their way to the rainforests of South America. In these warm, lowland regions, the sweet potato underwent further varietal differentiation, and in time, the intermixing and intercrossing of these original lines led to the formation of a highly complex cultigen.

Following the end of the Ice Age, the climate of the Peruvian coast became increasingly more arid, and by 4000 B.C., the present-day limits of the desert were reached (Bender, 1975; Sarma, 1974). The potato and sweet potato cultigens of the old savanna lands, however, continued to be cultivated in the moist river valleys and irrigated oases of the region. These small agricultural enclaves, as pointed out by Ugent et al. (1984, 1986), are of more than casual interest to us today, for within their narrow boundaries are preserved an important, partial record of the past.



Figs. 3 and 4. ***Top:*** **View of the Pampa de las Llamas-Moxeke site in the Casma Valley of Peru. The site is dominated by two large mounds, separated by a distance of 1.5 km.** ***Bottom:*** **The authors surveying the low, rocky mounds of a dwelling site at Pampa de las Llamas, where potato remains have been found. In the background is Huaca A. According to archaeologists Thomas and Shelia Pozorski, the walled chambers that stood on this mound in prehistoric times were used for the storage of potatoes, sweet potatoes, and other root crops.**

Archaeological Plant Remains and Sites

In the following sections, a brief summary is presented of the major archaeological sites where ancient remains of potato and sweet potato have been unearthed in Peru. Over half of the sites were explored jointly by the authors (Ugent and Peterson) in expeditions undertaken in 1987 and 1988; whereas several others were studied independently by the first author during visits to Peru in 1962, 1973, and 1985.

For the average traveler, a trip along the desert coastline of Peru can be an adventure in itself. The present-day coast is a narrow, arid strip of barren land, stretching some 2250 km and receiving less than an average of one centimeter of rain annually. Between the ocean and the mountains lie endless expanses of desert plain covered with dry, rocky pampa, majestic sand dunes, and high ocean cliffs, with intermittent, broad, sandy beaches and tiny rock-protected bays. From this coastal shelf, the Andes rise steeply, forming deep ravines with rivers gushing down through valleys and across the desert plain to empty out into the Pacific Ocean. It is here in these river valleys scattered along the coast that one finds the lush, green oases where Peru's early inhabitants first settled. This coastal area, however, takes on a special air of significance for the botanical explorer interested in the origins of potato and sweet potato, as it is here among the many prehistoric ruins and middens of this region that one of the oldest and most complete archaeological records of plant domestication in the world has been laid down and remarkably preserved.

Casma Valley. The principle sites where archaeological potatoes and sweet potatoes have been collected along the north-central coast of Peru are in the Casma Valley, located 360 km north of Lima. Three of the Casma Valley sites, Pampa de las Llamas, Huaynuma, and Tortugas, have yielded specimens of both sweet potato and potato, while the fourth site, Las Haldas, has yielded only potatoes.

One of the more impressive ruins in the Casma Valley is situated at Pampa de las Llamas (Fig. 3). This Early Ceramic site, which dates from the Initial Period (1800-1500 B.C.), is located inland on the Moxeke branch of the Rio Casma. It covers an area of about 220 hectares and includes two large mounds plus an extensive area of small mounds and homesites. According to archaeologists Thomas and Shelia Pozorski (1986), the two principal excavators of the site, the larger of the two mounds was probably used for administrative-religious purposes, while the smaller one probably functioned as a storehouse for the potatoes, sweet potatoes, and other crops that were being grown in a nearby, irrigated oasis. The settlement itself was built on dry desert sands.

Potatoes are well represented in the midden heaps that border the ancient homesites at Pampa de las Llamas (Ugent et al., 1982, 1983) (Fig. 4). Most of the dried potato samples that have been retrieved from this area are fairly small, ranging between 1 and 2 cm in size (Fig. 5). The tubers are typically round or ellipsoid in shape and have shallow eyes and smooth skin. Some show signs of being infected with scab and late blight disease.

Samples of sweet potatoes from Pampa de las Llamas, though represented mostly by broken ends and pieces, are generally of larger size than the extant potato collections. Most fragments range between 2 and 4 cm long, but whole specimens less than 2 cm in length have been reported (Ugent et al., 1981). Some root samples from Pampa de las Llamas were damaged by tunnel-forming beetles, and some beetle borings still contain remains of the dead insect pests. The potatoes and sweet potatoes of this site were probably prepared by baking around the periphery of an open fire. Many have charred or partially charred skin, and some still have small fragments of charcoal embedded in the skin or in the exposed cortex. These roots and tubers were eaten along with a wide variety of wild game and seafood, the bones and shells of which are of common occurrence in the middens of this site.

Other edible plant species that occur in the middens of Pampa de las Llamas include avocado, cansaboca, common bean, lima bean, edible canna, lúcuma, manioc, peanuts, pepper, and turban squash. In addition, the ancient inhabitants of this site are known to have cultivated cotton and bottle gourds.

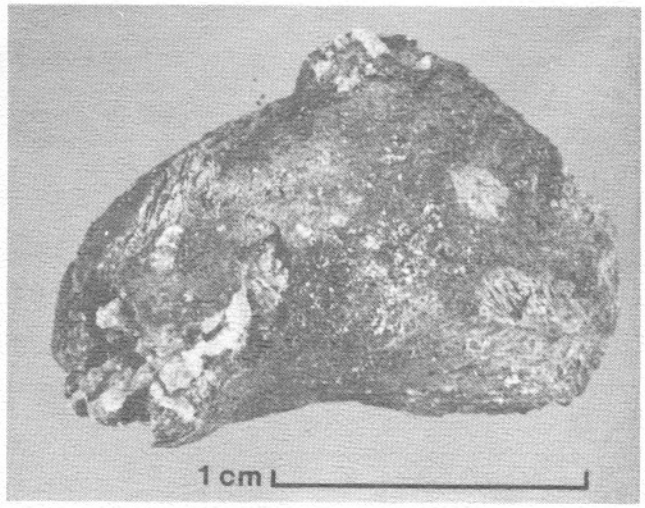
Due to the extreme aridity of the site, the preservation of plant parts at Pampa de las Llamas has been excellent. This has facilitated the study of both the external morphology of ancient potatoes and sweet potatoes, and their vascular anatomy and starch grains (Fig. 6).

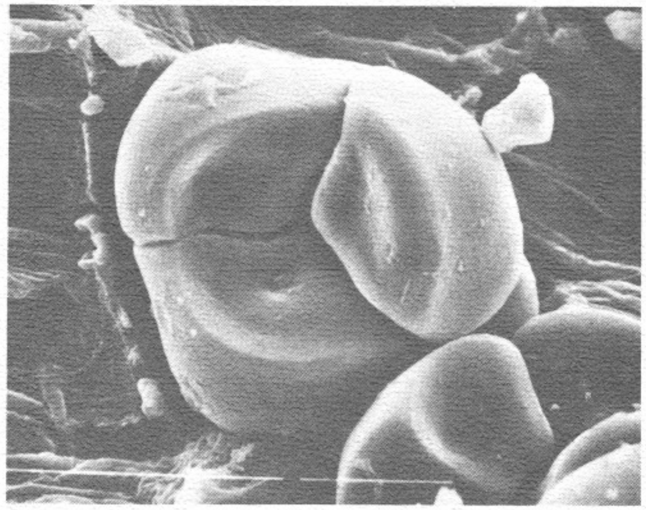
Another area of archaeological interest in the Casma Valley is Tortugas. This Early Ceramic site lies 20 km north of the city of Casma on a bay overlooking the ocean. Although much of the original site has been either destroyed or overlain by modern village construction, an area of undisturbed midden over one meter deep was discovered a few years ago by the Pozorskis. Samples from this midden were later sent to Ugent at Southern Illinois University for analysis.

A total of seven potato tubers and eight sweet potato roots were unearthed at the Tortugas excavations. All are similar in shape and form to the collections from Pampa de las Llamas and were probably originally grown at that site. Since fresh water for irrigation is not available at Tortugas, it is probable that this site was used mainly as a base for fishing operations. Trade between the two villages, one located inland and the other ocean-side, would then account for the presence of marine resources at Pampas de Las Llamas and agricultural products at Tortugas.

Other crop plants found in the midden at Tortugas include avocado, bottle gourd, cansaboca, common bean, lima bean, cotton, guava, lúcuma, manioc, peanuts, and turban squash.

One of the least conspicuous ruins in the Casma Valley is Huaynuma. This Preceramic (ca. 2000 B.C.) coastal site is located on a small protected bay just a few kilometers north of the previously





Figs. 5 and 6. *Top:* A 3500-year-old potato tuber from Pampa de las Llamas-Moxeke in the Casma Valley. As seen in the lower left-hand corner of the photograph, a portion of the dried cortex has been exposed as a result of natural shrinkage and breakage of the tuber skin. Salt crystals have also accumulated in the other broken areas and lesions of the skin. Internally, the starchy cortex remains in near perfect condition. *Bottom:* Scanning electron micrograph of a compound, sweet potato starch grain (gold-palladium coated: 2000 ×). This sample was obtained from one of the prehistoric roots that was unearthed at the Initial Period site (1800-1500 B.C.) of Pampa de las Llamas by the Pozorskis. The number, size, and shape of the small granules that comprise the larger starch grain are characteristics of this species.

List of Common Plant Names and Scientific Descriptions

Name in article	Scientific name	Other common name(s)
Achote	*Bixa orellana* L.	achiote, anatto
Ahipa	*Pachyrhizus ahipa* (Wedd.) Parodi	ajipa, jicama, yam bean
Algarroba	*Prosopis chilensis* (Mol.) Stuntz	algaroba, mesquite
Avocado	*Persea americana* Mill.	palta
Bottle gourd	*Lagenaria siceraria* (Mol.) Standl.	calabaza, maté
Cansaboca	*Bunchosia armeniaca* (Cav.) DC.	ciruela de fraile, ciruelo del fraile
Caña brava	*Gynerium sagittatum* (Aubl.) Beauv.	uva grass
Cat-tail	*Typha angustifolia* L.	enea
Common bean	*Phaseolus vulgaris* L.	frijol
Coca	*Erythroxylon coca* Lam.	cocaine plant
Corn	*Zea mays* L.	maize, maíz
Cotton	*Gossypium barbadense* L.	algodón
Crookneck squash	*Cucurbita moschata* Duch.	calabaza
Edible canna	*Canna edulis* Ker-Gawler	achira
Fig-leaf gourd	*Cucurbita ficifolia* Bouché	chilacayote
Guava	*Psidium guajava* L.	guayaba, guayabo
Lima bean	*Phaseolus lunatus* L.	pallar
Lúcuma	*Lucuma bifera* Mol.	lúcumo
Manioc	*Manihot esculenta* Crantz.	yuca, cassava
Nectandra	*Nectandra reticulata* (R.&P.) Mez	muena, laurel
Oca	*Oxalis tuberosa* Mol.	oka
Olluco	*Ullucus tuberosus* Caldas	ullucu, papa lisa
Pacae	*Inga feuillei* DC.	pacay
Papaya	*Carica papaya* L.	lechosa
Peanut	*Arachis hypogaea* L.	maní
Pepper	*Capsicum* spp.	ají, chili
Potato	*Solanum tuberosum* L.	papa
Prickly pear	*Opuntia* spp.	tuna
Quinoa	*Chenopodium quinoa* Willd.	quinua
Reed	*Phragmites communis* Trin.	carrizo, carrizo de muerto
Sedge	*Cyperus* spp.	junco
Soapberry	*Sapindus saponaria* L.	cholloco, choloque
Sweet potato	*Ipomoea batatas* (L.) Lam.	camote
Tillandsia	*Tillandsia gilliesii* Baker	tilandsia
Turban squash	*Cucurbita maxima* Duch.	zapallo
Vilfa	*Sporobolus virginicus* (L.) Kunth	dropseed grass
Willow	*Salix chilensis* Mol.	sauce

Note: Common names follow Herrera (1939), Sagastegui Alva (1973), Terrell (1977), Weberbauer (1945), and Yacovleff and Herrera (1934).

described ruin and 13 km north of the Casma Valley. Although no large mounds or above-ground walls are visible at Huaynuma, an ashy-gray mantle of midden, about 2 meters deep in places, is spread across the dry, light-colored sands for an area of about three hectares. In addition to plant material, the midden layer at Huaynuma contains a large assortment of shells and fish and marine animal bones. Since there are no fresh water streams available for the irrigation of vegetable crops near the site, it would appear that the harvesting of marine resources was the chief activity of its early inhabitants. As in the case of Tortugas, the residents of Huaynuma probably obtained food and fiber plants by trading marine goods inland along the Casma Valley. Six potato tubers and one sweet potato root were among the various plant remains that were retrieved by the Pozorskis from test pits dug into the middens of this site. This material was sent to Southern Illinois University where it was later identified to species level by Ugent.

The above samples of potato and sweet potato from Huaynuma are the most northerly known for these two species. In addition, these specimens are of interest to science as they represent the oldest-known archaeological collections of potato and sweet potato from the north coast.

Other crop plants that appear in the broad mantle of midden at Huaynuma include bottle gourd, cotton, edible canna, lúcuma, pepper, fig-leaf gourd and turban squash.

The fourth place of interest in the Casma Valley is Las Haldas. This large and impressive coastal site, located about 30 km south of Casma, covers forty hectares. It is situated on top of a high seaside cliff with a panoramic view of the ocean and includes a large temple mound overlooking a central plaza with a sunken circular arena, as well as extensive areas of midden.

Although sweet potato has not yet been recovered from Las Haldas, three small potato tubers were unearthed by the Pozorskis from an Initial Ceramic Period (1600-1200 B.C.) midden at the temple site. These were included among the various plant remains that were later forwarded to Ugent for analysis.

Other crop remains associated with the above-mentioned potato specimens include avocado, bottle gourd, common bean, corn, cotton, edible canna, guava, pacae, lúcuma, manioc, peanut, and turban squash. As in the case of the two fishing village sites of Tortugas and Huaynuma, fresh water was also not available for crop irrigation at Las Haldas. It is possible that the original inhabitants made a living by exchanging marine products for vegetable goods. The presence of abundant shells, fish bones, and sea mammal remains, as well as crop plants in the Las Haldas middens, would seem to support that theory.

Paramonga and Ancón. Heading south from Las Haldas toward Lima, one comes across two other famous archaeological sites, Paramonga and Ancón, located along the Panamerican Highway. The first mentioned site, Paramonga, lies in a broad, fertile, irrigated valley some 185 km north of Lima. This site, which contains a Chimú temple (Chimú culture, A.D. 1000-1470) set on a fortress-like mound, may have served its ancient inhabitants as an administrative-religious center and fortress. However, as the ruins in this area have never been excavated, our many questions concerning the lives of the people who once lived here and the plants that they cultivated still remain unanswered.

One of the last coastal urban centers that one sees from the Panamerican Highway prior to entering Lima from the north is the modern seaside village of Ancón. Just to the east of this resort town is situated an ancient burial ground called the Necropolis. These burial grounds, dating from the Late Intermediate Period (A.D. 1000-1500), were in turn situated near the site of an ancient fishing village and the fertile fields of the Chillón Valley. The cemetery itself was excavated in the late 1800s by two German archaeologists, Wilhelm Reiss and Alphons Stübel (1800-87). They found numerous plant offerings interred with the mummified remains of the original inhabitants. One of the cultigens discovered in this manner, according to botanist Ludwig Wittmack (1880-87), who was responsible for the identification of the Ancón plant collections, was the sweet potato. Other crops identified by Wittmack as occurring in this same collection were bottle gourd, common bean, guava, lúcuma, maize, manioc, pacae, peanuts, quinoa, soap berry, and turban and crookneck squash.

Specimens of sweet potato dating from the Late Cotton Preceramic period (1900-1750 B.C.) have also been discovered at Punta Grande in the Chillón Valley, as well as from the Late Cotton Preceramic and Early Ceramic levels of the Tank site (Cohen, 1978; Lanning, 1965, 1967; MacNeish et al., 1975; Patterson, 1971; Patterson and Moseley, 1968).

The first author of this paper recently had the opportunity to examine additional plant materials that were associated with the mummified human remains studied by Reiss and Stübel, but which were not reported upon by Wittmack. These collections, stored at the Berlin Museum für Volkerkunde, include a number of economically useful wild species (such as willow, caña brava, nectandra, tillandsia, and vilfa grass), as well as cotton and papaya, two crop species that had been overlooked previously.

Pachacamac. South of Lima there occur four sites where archaeological potatoes have been found, and five where ancient sweet potatoes have been collected (*see* map). One of these sites, Pachacamac, is situated 31 km south of Lima on a bluff top with an expansive view of the ocean and the Lurín river valley. This late Inca ruin (A.D. 1000-1500) overlies earlier ruins, and includes two large mounds, the Temple of the Sun and the Temple of Pachacamac, as well as numerous smaller mounds, residential structures, and administrative buildings, some of which are currently undergoing restoration and further excavation.

Potato tubers were first discovered in the extensive middens of Pachacamac by the German archaeologist, Max Uhle. These were described by Harshberger (1898) as being comparable in size to any one of a number of modern wild potato species. Harshberger, however, made no allowance for shrinkage, which is an important matter in evaluating tuber remains, since potatoes are typically comprised of 80% to 90% water. Tubers examined by Towle (1961) and Ugent et al. (1982) also confirm the existence of the potato at Pachacamac (Fig. 7) and point to the relatively high stage of domestication that was obtained in the plants of that era (as deduced from their large, rounded starch grains).

A single, whole sweet potato root collected by Ugent at Pachacamac in 1973 had been riddled by beetles, but was otherwise found to have a cortex that was preserved in nearly perfect condition (Fig. 8). The starch granules of this 6-cm long root are similar in size and shape to those produced by the modern sweet potato.

Other crop plants known from the extensive middens of this site include bottle gourd, common bean, lima bean, peanut, maize, pepper, and cotton.

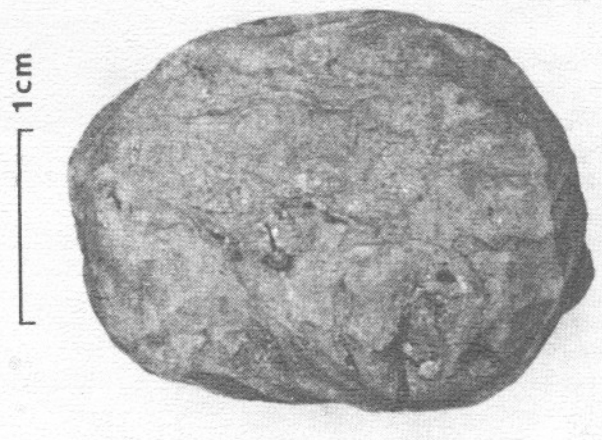


Fig. 7. Potato tuber from the ruins of Pachacamac. This wholly intact specimen, collected by the first author from the Late Inca Period midden that borders the Temple of the Sun, owes its exceptional preservation to the extreme aridity of the site.

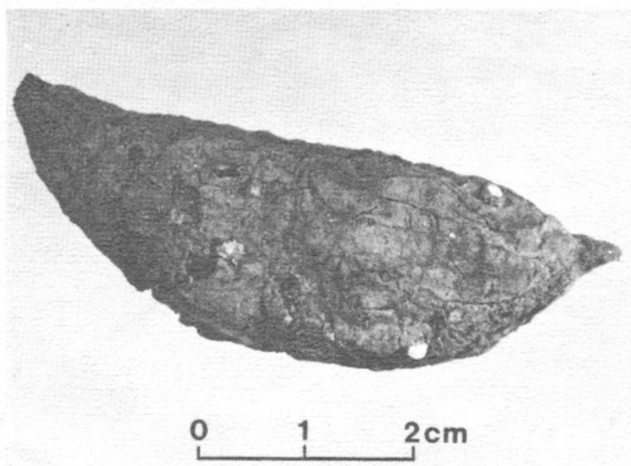


Fig. 8. Dried sweet potato root from the Temple of the Sun site at Pachacamac. As in the case of many other root samples of this species that have been unearthed from kitchen middens, the cortex and skin of this Late Inca Period (A.D. 1400-1532) specimen of the sweet potato have been bored through by beetles.

Chilca Canyon. Southeast of Pachacamac and 65 km south of Lima lies the next site where the remains of both potato and sweet potato have been discovered—the caverns of Chilca Canyon. According to Engel (1970), the cave sites at Tres Ventanas were occupied as early as 8000 B.C. Excavation of the lowest levels of one of the caverns at Tres Ventanas has yielded samples of the cultivated potato (Ugent et al., 1982), sweet potato, olluco, jicama, bottle gourd, and prickly pear. If the stratigraphy of this site is accurate, the specimens collected by Engel represent the oldest remains of these economically important plants presently known to science. Engel's methodology, however, has been criticized by Bonavia (1984).

La Centinela. Other remains of the potato and sweet potato have been discovered recently by the authors at La Centinela, a pre-Inca ruin located about 200 km south of Lima in the lower part of the fertile Chincha Valley. This site covers an area of thirty hectares and is surrounded by an irrigated agricultural zone that extends from the western side of La Centinela down to the Pacific shoreline, about one kilometer in distance (*see* Fig. 1). The ruin consists of 11 major, clearly defined pyramid structures and other minor buildings that are supported by thick walls of adobe construction. According to Menzel and Rowe (1966) and Santillana (1984), the relatively late Inca structures that dominate this ruin overlie construction that dates back to the Kingdom of Chincha (ca. A.D. 1000-1476), which was an economically prosperous coastal society prior to its conquest by the Incas in the late fifteenth century.

Several potato samples were unearthed from a midden at this site (Fig. 9) by the authors. The largest sample is a skinned, half-tuber portion weighing 3.48 g. This piece measures 21 by 25 mm at its semi-circular cut end, and 12 mm from end to end. The two sweet potato samples that were unearthed from this same midden weighed 0.89 g and 1.05 g. The smaller was about 30 mm long and about 12 mm in diameter at its widest point, while the larger was 37 mm long and about 13 mm in diameter at its widest point. Both roots were riddled with beetle borings.

In addition to the remains of the potato and sweet potato, the authors also found signs of a number of other plant, animal, and marine resources that were being used by the inhabitants of La Centinela. These include the leaves, husks, inflorescences, and cobs of the corn plant, peanut shells, and lima beans, as well as shellfish and guinea pig bones. All were contained in a large, 30-cm thick midden located in a deep test pit near the base of one of the large pyramid structures.

Fig. 9. Midden deposit at La Centinela. The dark, organic layer that is exposed along the periphery of this pit dates from the Chincha Period (ca. A.D. 1000). It contains a variety of plant parts, including dried avocado fruits, bean seeds, potato tubers, sweet potato roots, and the ears and husks of maize.

Four of the twelve corn-cobs that we collected at the above midden were sent to Beta Analytic Inc. (Coral Gables, Florida) for radiocarbon dating. The results of this contractual work, funded by a grant from the International Potato Center, indicate that the contents of this midden were deposited about 880 (±80) years ago. This date corresponds to the period of the Chincha tradition at La Centinela. Although the discovery of potato and sweet potato remains at La Centinela adds to our general knowledge of the distribution and variation of both crop plants in prehistoric times, these facts would seem to hold special meaning for the potato—for La Centinela is the most southerly known site along the coast of Peru where this species is known to have been utilized for food in ancient times.

Paracas. Fifty kilometers due south of La Centinela lies the Paracas Peninsula, which provides shelter for the Bay of Paracas on the northern side of the peninsula. It is here in this desert peninsula, overlooking the bay, where the Paracas Necropolis is located. This burial site is well known for its walled, underground tombs and well-preserved remains of mummy bundles. Beautifully made ceramic vessels have been unearthed at Paracas, as well as some of the finest examples of the art of tapestry-making that are known to the world. Tello (Nordenskiold, 1931) reported that dried sweet potato roots were discovered at the Paracas Necropolis during his excavations of the underground burial chambers. These grave offerings were found in association with a wide variety of other crop and economically useful plants, including ahipa, algae, cat-tail, caña brava, coca, common bean, cotton, gourd, maize, manioc, pacae, peanut, pepper, and reeds and sedges.

Although no general collecting of plant remains was undertaken by the writers in their visit to the Paracas Necropolis in March 1988, two corncobs complete with dark purple-colored kernels were retrieved from the surface sands of the site. One sample weighing 17 g was sent to Beta Analytic Inc. of Coral Gables, Florida, for radiocarbon dating. This subsequently proved to be 2390 (±120) years old. The remaining sample (19.7 g), one kernel of which was taken for use in a scanning electron microscope (SEM) study of starch grains, is now housed in the economic botany collection at Southern Illinois University. As in the case of the previous radiocarbon dating for La Centinela, the funding for the present investigation was graciously provided by a grant from the International Potato Center.

Ocucaje and Nazca. The last two sites where archaeological sweet potatoes have been discovered are found inland from the Paracas Peninsula. The first is

Ocucaje in the Ica Valley, about 335 km from Lima; the second, Cahuachi in the Nazca Valley, is situated 100 km further to the south. Towle (1961) reports that dried sweet potato roots have been found in grave sites at Ocucaje (A.D. 1-600), together with offerings of guava, lima bean, maize, pacae, peanut, and squash. Even more extensive, however, is the list of useful plants and cultigens recovered from middens surrounding the ruins of Cahuachi (750 B.C.-A.D. 1). According to Towle, the archaeological record of this area includes all of the above species plus achote, algarroba, avocado, cholloco, common bean, cotton, edible canna, gourd, and manioc. Cahuachi, at present, is the most southernly known site where archaeological specimens of sweet potato have been collected.

Opportunities for Future Research

Few studies, to date, have been made on prehistoric remains of potato and sweet potato. And yet, probably no other field of investigation promises to reveal so much with respect to the botany and horticulture of these two crops. In particular, the pathogens that attacked these ancient food plants should be examined. These organisms have experienced a history of more than 4000 years of mutation following their appearance at these prehistoric agricultural sites. A study of these ancient pathogens could give us a better idea of their early development and perhaps a clue as to their primordial states.

Many of the tubers and tuberous roots that have been studied by the first author show damage from blight, and some still preserve internal networks of hyphae. Virus, nematode, scab, and insect damage are other areas of research that have not been investigated previously. Knowledge of these ancient diseases and pests may prove helpful in finding better ways of dealing with their modern counterparts.

Still another area of investigation that is currently awaiting study concerns the phylogenetic relationships of the cultivars. The same electrophoretic methods that are now being used to identify the proteins of the modern cultivars could also be extended easily to cover the relationships of their more primitive ancestral stocks. Additional data could also be derived from DNA analysis. The information derived in this manner may be useful in gaining a better understanding of the botanical origins and gene structure of our modern cultivars and may ultimately serve us in a practical way through the breeding of better crops.

Lastly, it should be pointed out that the field of archaeological crop exploration is still in its infancy. Much remains to be done with respect to the dating, collecting, and identification of cultivar remains from coastal Peru, and especially from the ruins situated in the extreme northern or southern provinces of the country. With the obtaining of an additional data set on the distribution and genetic variations of the potato and sweet potato in ancient times, scientists may come to a greater understanding of how these two crop plants, which are of worldwide importance today, evolved under the selective and protective influences of man.

These findings could also tell us something about crop management for the future. For example, the discovery of disease-free material of ancient potato and sweet potato in specific geographic areas might indicate that natural biological control mechanisms were operating, or that the farmers themselves in some areas were using better methods of crop management. A statistical survey conducted on archaeological materials recovered from various sites drawn from both the north and south regions of Peru would give us some indication of areas where the crops were subjected to differential pest and disease pressures.

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Training Activities

Training Courses Held

Region I—A *Workshop on Improving the Ability to Diagnose Production Systems of Root and Tuber Crops* was organized by CIAT and held at Cartagena, Colombia, September 12-16, to bring together cassava, sweet potato, and potato researchers who have participated in integrated production-utilization projects or who are just beginning field-level diagnostic work. This workshop was a CIAT-CIP activity within Joint Activity No. 3—Training on Farm-level Diagnostic Skills—of the CIAT-CIP-IITA project on Human Resource Development for National-Level Generation and Transfer of Root and Tuber Crop Technology, funded by the United Nations Development Programme (UNDP) for three years from January 1988. Nineteen scientists from ten Latin American countries, and six CIAT and one CIP staff shared experiences and exchanged information on the diagnosis of field-level problems. Participants were then divided into three groups to study production, processing, and marketing, and to do practical field work. Each group prepared conclusions and recommendations from their field study for discussion by the entire workshop group. The participants stated a need for training in methods of data collection, sampling, data analysis, and the interpretation of research results.

Region II—A *Germplasm Management Course*, organized in Mexico by the PRECODEPA country network and financed by CIP, took place at Toluca from August 15 to 26. Five Mexican scientists attended and one each from the following PRECODEPA countries: Costa Rica, Dominican Republic, El Salvador, Guatemala, and Panama. A Colombian and two Bolivian scientists, in Mexico for training in seed production, attended the second week of the course, which dealt with breeding and screening for resistance to the major diseases and pests, and adaptation of the potato to warm climates.

Region III—An in-country *Potato Seed Production Course* was held at the Holetta Research Center in Ethiopia, August 23-26. Thirty-five participants attended from eleven different organizations, including government ministries, Alenaya University, agricultural colleges, and a farmers' training center.

Region IV—A one-week course on *Potato Seed Production and Storage* was organized by the Turkish national potato program and held August 15-19 at the Aegean Regional Agricultural Research Institute, Menemen, Izmir, and at Bozdag. The course, attended by 12 seed specialists, was taught in Turkish and English.