MANIOC CULTIVATION AT CEREN, EL SALVADOR: OCCASIONAL KITCHEN GARDEN PLANT OR STAPLE CROP?

Payson Sheets, Christine Dixon, Monica Guerra, and Adam Blanford

Department of Anthropology, University of Colorado, Boulder, CO 80309–0233

Department of Geology, University of Colorado, Boulder, CO 80309–0233

Abstract

Many scholars have thought the Classic period Maya did not cultivate the root crop manioc, while others have suggested it may have been an occasional cultivar in kitchen gardens. For many decades there was no reliable evidence that the ancient Maya cultivated manioc, but in the 1990s manioc pollen from the late Classic Archaeo was found in Belize, and somewhat older pollen was found in Tabasco. At about the same time of these discoveries, research within the Ceren village of El Salvador encountered occasional scattered manioc plants that had grown in mounded ridges in kitchen gardens. These finds are consistent with modern households indicating manioc was not a staple crop, and rarely inferior to maize and beans in food volume and nutritional value. However, 2007 research in an agricultural area 200 m south of the Ceren village encountered intensive formal manioc planting beds. If manioc was widely cultivated in ancient times, its intensive productivity, ease of cultivation even in poor soils, and drought resistance suggest it might have been a staple crop helping to support dense Maya populations in the southeastern periphery and elsewhere.

UNQUEEN ANS, AND UNANSEWED QUESTIONS: MAYA AGRICULTURE AND POPULATION

Beginning with the Spanish in Yucatan in the early sixteenth century and continuing to the mid-twentieth century, Westerners observed the Maya living in dispersed settlements scattered thinly across the landscape. Furthermore, in Colonial period and later times Westerners consistently recorded Maya agriculture as a shifting swidden system focusing on maize supplemented by beans and squash. However, the 90–45% population reduction following the Spanish conquest (Dobyns 1966) indicates that agricultural practices observed in the colonial era may have been quite different from pre-Colombian times. As recently as the mid-twentieth century, Westerners extolled that same settlement pattern and agricultural system back into the ancient Maya past. The predominant understanding of Classic Maya settlements emphasized dispersed populations that occasionally coalesced for religious observances in the otherwise "empty" ceremonial centers. The mid-twentieth-century discoveries of high structure densities, interpreted as high population densities, challenged archaeologists to answer the question "how did the Maya feed the multitudes?" Archaeologists then focused on how to answer that question by considering other cultivars and agricultural strategies.

THE UNQUEEN SEW: EXTENSIVE MAIZE MILPA

Westerners’ understandings of ancient Maya food production have undergone major transformations during the past five centuries. The predominant view of ancient Maya agriculture during the ninth and early-to-mid-twentieth centuries was an extensive swidden cultivation of maize, with beans and squash as secondary crops, as noted by Harrison and Turner (1978), Turner (1978), and Sharry (1994, 2006). The origins of this view can be traced back to the mid-sixteenth century when Bishop de Landa described the Maya in the northern Yucatan peninsula relying on maize, slash-and-burn field preparation, and planting multiple maize seeds per digging stick hole (Gates 1978:36–39). Bishop de Landa also mentioned beans, peppers, and unnamed root crops (Gates 1978:103). De Landa did not specifically describe swidden agriculture, but his and other people’s descriptions during colonial times contributed to the understanding that the Maya fed themselves from dispersed non-intensive agriculture. Early assumptions of ancient Maya swidden agriculture in the Maya area were further supported by accounts of travelers, such as Thomas Gage (Thornton 1958), and Stevens and Catherwood (1841), observing the Maya successfully feeding dispersed populations by non-intensive agriculture. As Turner (1978) noted, Stevens argued for continuity by stating that the cultivation of maize by the nineteenth-century Maya probably differed little from that of the ancient Maya.

Archaeologists consolidated the argument for ancient Maya swidden system in the late nineteenth and early twentieth centuries by observing the traditional Maya cultivating extensive milpas and feeding dispersed populations. Morley (1946) more firmly...
implanted the swidden-maize-mipil model in our discipline by arguing that there had been no changes in agriculture over three millennia. The Swidden-maize-mipil model was the unquestioned answer to how the Classic Maya fed themselves.

The Unanswered Question: How Did the Maya Feed Themselves?

The recognition of dense Maya populations was slow in developing. As Webber (2002:173) noted, an employee of the American Chick Company named Paul Scheffeld observed vast numbers of small house structures and conveyed that to Sylvanus Morley in 1921. Morley “violently disagreed” with that observation, and stated he would not dare express such an observation back in Cambridge (Webber 2002:173). Decades later Morley changed his mind and suggested breathtakingly high population estimates for the Classic Maya (Webster 2002). A few scholars in the early twentieth century, such as Diller and von Hagen, recognized small mounds as probable remains of common houses in the southern Maya lowlands (Harrison and Turner 1978). However, that recognition was qualitative, and quantitative aspects (i.e., density of structures per unit area, and inferred population densities) awaited settlement pattern studies of the mid-twentieth century.

The question to the unexplained answer of dispersed milpa came not from direct archaeological discoveries of ancient agriculture, but through the “demographic back door.” Archaeological projects in the 1950s initiated by Caraco, Douglas, and Woodard (1959) and others (e.g., Birk 1953) during the 1950s and 1960s included intensive surveys that found vastly greater structure densities, interpreted as high population density, than previously recognized (Willey 1952; Willey and Hunt 1952). Culbert and Rice (1990) summarize numerous paleodemographic estimates of hundreds of people per square kilometer at many Classic period sites derived from those surveys. Stover (1980:688) presents population densities from about 200 to 400 people per km² for many sites. Webber (2002:174), among the most conservative of current Mesoamericanists in estimating population, states “if even the lower figure of 100 km² is accepted” it provides “a good idea of what the inhabitants of the Mayan area, states “even the lower figure of 100 km² is accepted.” In fact, the number of people per km² is a common metric used to compare and contrast ancient and modern settlement patterns. The fact that the Maya were understood to have been small and scattered, while the ancient Maya were seen as an agricultural people with large populations, became a significant change in the way we think about ancient Maya society.

Maya Collapse: Whether or Not?

Scholars have long been interested in the collapse of Classic Maya society. The collapse of the Classic Maya is a phenomenon that has been studied extensively by archaeologists and historians for decades. However, there is still much debate about the causes and consequences of the collapse.

The collapse of the Classic Maya is a term used to describe the decline of the Maya civilization during the Late Classic period (AD 800-1000). The collapse is characterized by a dramatic decrease in population, the abandonment of major cities, and the decline of large-scale agricultural and political organization. The causes of the collapse are still a subject of debate among scholars, but some of the proposed factors include environmental degradation, political instability, and external attacks.

In recent decades, scholars have found micro- and macroscopic evidence of cultural collapse. Madsen (1991:180) identified some carbonized organic materials at Cuello as fragments of manioc stems, and that was confirmed by the use of radiocarbon dating. Madsen (2001) noted the remarkable resilience of the Maya, and that they were able to adapt to the changing conditions and continue to thrive. In fact, the collapse of the Classic Maya was not as abrupt as initially thought, and there were periods of recovery and revival, such as the Terminal Classic and Postclassic periods.

In conclusion, the collapse of the Classic Maya is a complex phenomenon that involved a combination of internal and external factors. The reasons for the collapse remain a subject of ongoing research, but the resilience of the Maya and their ability to adapt and recover is a testament to their ingenuity and resourcefulness.
Intensification among traditional smallholders consistently is more pronounced near their households, such as the "high perform-
ance" hills of Wilkins (1971), and usually diminishes with distance as one enters the outskirts (Robert Netting, personal communication 1985). Our hypothesis in 2007 was that agricultural intensification and productivity would decline in fields a few hundred meters south of the village. The results did not support that hypothesis. The maize field encountered in Test Plot 5 and 6 was as intensive as those found within the site center. And the most important dis-
cover, that certainly did not support the hypothesis, was the inten-
sive manioc planting field discovered in Test Plot 1 (Figure 2) and 2. The field is located in the Middle Classic period, about 600 m, in the wetter by the Loma Caldera volcanic ash at the same time as the Cerén village (Miller 2002; Sheets 2002). Prior to describe the excavated manioc field at Cerén, consideration needs to be given to manioc itself, and its needs in terms of soils, moisture, and temperature.

MANIOC BOTANICAL CHARACTERISTICS AND EDAPHIC REQUIREMENTS

Numerous varieties of wild manioc, genus Manihot, are common to the New World tropics from Mexico to the Amazon (Rehm and Espin 1991). Domesticated manioc is a small tree or bush that pro-
duces large carbohydrate-rich roots and edible leaves. Botanically classified as Manihot esculenta, manioc is locally known as "yuca" in Central America or "casava" in South America (Hansen 1983). The bush usually grows to 2-3 m tall, with long slender stems and long finger-like leaves. The leaves contain 15-25% proteins (Hansen 1983), and thus are a potential source of crude protein. Eight native South American groups consume manioc leaves (Defoer 1994:177). A hectare of manioc can produce and fix 3 to 5 tons of protein per year (Moore 1976; Toror and Afife 1985:208; Toror and Afife 1985:208; and Cock 1982:575, 575) report manioc tuber harvest yields of 80 tons per hectare, but the average yield of cassava worldwide is 9-10 tons per hectare. These figures apparently are harvest-
weights, not dry weights, and assuming comparabil-
ity (2008) states, the tubers contain 65% water, while maize contains 11% water. Most contemporary plots of manioc contain 5,000 to 20,000 plants per hectare, with a variety of about 10,000 (Toror and Afife 1985:224-226). Most of the vol-
ume of the plant is underground, in the form of roots that thicken into large, thick stems. Manioc tubers grow in clus-
ters of five to ten tubers from each plant (Hansen 1983), and the dried tubers are 85% carbohydrates, less than 2% protein (Cock 1982), and are a major dietary source for many indigenous peo-
ple (Hansen 1983). Tubers grow to a half-meter or more in length. Manioc is notable for requiring less effort in planting and tending, and is more drought-resistant, than the other
Mexican food crops (Rehm 1968).

Once harvested, manioc tubers must be consumed within a few days before they deteriorate. This storage of large amounts of a product unless they are processed into dry flour, which does store well. However, smallholders observed by Sheets in El Salvador readily solve what would be a storage problem by only harvesting what is needed for immediate consumption, leaving the remainder in "storage" still growing underground. Being a perennial, manioc grows for a few years, and once mature the tubers can be harvested at any time during the rainy or dry season. During a long dry season or a drought the plant ceases to grow, but the tubers remain edible and available. Thus in times of stress it is an ideal carbohydrate source from the roots, and protein from the leaves, when other sources fail. It can be cultivated up to 2,000 m of altitude, and makes its own decisions regarding how, when, and what to plant as well as how to maintain sustainability over long periods of time. They often are dependent on their pack animals for transportation, and are a substan-
tial contribution to the exportation not by expansion of land but by increasing labor or changing technology. The advantages to the smallholder of growing both seed and food crops are climatic variations or pests afect different cultivars. However, if decision making and/or land ownership were super-household, and harvesting were done in one place, storage of manioc tubers becomes problematic as they last only a few days above ground. To last longer the tubers need to be ground and dried. To date no evidence of manioc tuber drying is known in the Maya lowlands, and the nature or degree of elite control of manioc farming is completely unknown, but future research will be exploring this important topic. If house-
holds are centrally controlled, decision-making should be based on discernible boundaries, and paths should be found leading toward individual households. Alternatively, if land ownership is at the community level or central authority, roads should extend over larger areas without subdivisions, and paths would be more communal. Harvesting presumably would be more simultaneous over a larger area, with decisions made within different households. Webber (2002:175) argues that the greatest ignorance about ancient Maya agriculture is in this domain of political economy. Did the household or the community own the fields, or was their use left to the individual or to the user? At what level was decision-making done? Were commoner-elites relations coercive or were they volitional and symbiotic?

2007 RESEARCH: AGRICULTURE SOUTH OF CEREN

The 2007 archaeological investigations at Ceren have significantly our understanding of agriculture at the site. The first step in the 2007 research was to accurately map the research area, consisting of Lots 190, 191, and 192 to the south of the Joya de Ceren archaeological site (Figure 1). Adam Blanford conducted the surveying by theodolite. Two geophysical grids within the survey were surveyed with particular care (Sheets et al. 2007).

Monica Garnett and Adam Blanford, with the assistance of Christine Dixon. They used a state-of-the-art ground-penetrating radar to survey an area of about 100 meters by 100 meters, totally 200,000 square feet, which would have been densely inhabited in the Middle Classic period. Two 100-meter by 100-meter grids were surveyed, the larger in Lot 191 and the smaller in Lot 192. However, the radar and the excavation crews were not able to link them.

Dozens of geophysical anomalies were encountered within these grids, and along the linking transects. Some apparently are natural, as many varieties of root and rod-like features were visible in the grids during the a.d. 600 Loma Caldera eruption, and became visible in the soil as ca. 3 m of volcanic overburden. They are rather strong point source reflectors. Other anomalies apparently were created by the natural changes in landforms that existed prior to the eruption, and variation in subsurface drainage and sediment properties. We used eleven core drillings to calibrate radar data of transmission of depth to, and verify our interpretation that we were correctly identifying Classic period ground surface in the imagery. After this drilling was completed, collection of test pits was excavated in places of interest. Each test pit measured 2 x 2 m, with the long axis oriented north-south, and was excavated through 3 m of the Loma Caldera volcanic ashes down to the Classic period ground surface contemporary with the Cerén village some 200 m to the north. The rationale for doing paired test pits was to expand finding large pits, and make their own decisions regarding how, when, and what to plant as well as how to maintain sustainability over long periods of time. They often are dependent on their pack animals for transportation, and are a substan-
tial contribution to the exportation not by expansion of land but by increasing labor or changing technology. The advantages to the smallholder of growing both seed and food crops are climatic variations or pests afect different cultivars. However, if decision making and/or land ownership were super-household, and harvesting were done in one place, storage of manioc tubers becomes problematic as they last only a few days above ground. To last longer the tubers need to be ground and dried. To date no evidence of manioc tuber drying is known in the Maya lowlands, and the nature or degree of elite control of manioc farming is completely unknown, but future research will be exploring this important topic. If house-
holds are centrally controlled, decision-making should be based on discernible boundaries, and paths should be found leading toward individual households. Alternatively, if land ownership is at the community level or central authority, roads should extend over larger areas without subdivisions, and paths would be more communal. Harvesting presumably would be more simultaneous over a larger area, with decisions made within different households. Webber (2002:175) argues that the greatest ignorance about ancient Maya agriculture is in this domain of political economy. Did the household or the community own the fields, or was their use left to the individual or to the user? At what level was decision-making done? Were commoner-elites relations coercive or were they volitional and symbiotic?

Miomik Planting Beds Discovered in Test Plot 1 & 2

Test Pits 1 and 2 were located toward the eastern end of GPR Tie Lines 1 and 3, and were excavated in the east-west direction because they were on the GPR tie lines between the survey grids, and digging them at this locality would create minimal agricultural disturbance to modern sugarcane cultivation. Excavations showed that manioc planting beds, the second encountered an area where manioc evidently had been cultivated years before the emi-
tion but had been converted to an open activity area, and the third pair encountered a mirola with manioc approaching maturity.

Miomik Planting Beds (deposited in Test Plot 1 & 2)

Figure 2. Manioc planting beds buried by the tepos from the Loma Caldera eruption. Test Plot 1. Christine Dixon is on a flat, hand-packed "calic" or worldview, with a large planting ridge in front of her. The white spot in the background is the foregarden that is plastered pavement into a clay line where a manioc planting bed is exposed slightly after the eruption. The entire sites are labeled on the right, with the odd number plots being dug to the same depth as the even plots. The even numbers are darker and corner layers representing air falls, 2007:191, and 192 to the south of the Joya de Ceren archaeological site (Figure 1). Adam Blanford conducted the surveying by theodolite. Two geophysical grids within the survey were surveyed with particular care (Sheets et al. 2007).

Monica Garnett and Adam Blanford, with the assistance of Christine Dixon. They used a state-of-the-art ground-
Manioc Cultivation at Cerén, El Salvador

Figure 4. Dental plaster cast of two overlapping manioc tubers that were mixed in the harvesting that took place immediately before the Loma Caldera eruption, from Test Pit 2. Scale is 8 cm long.

Figure 5. Profile of west wall, Test Pit 1, showing stratigraphy of the Loma Caldera eruption, and the manioc planting beds separated by the "cañas".

Figure 6. Monica Guerra holding a dental plaster cast of a manioc plant stalk (A) that had been cut and planted horizontally in the bed in Test Pit 1. Notice robustness of the stalk; below is a fresh manioc tuber (B) purchased in the local market for comparison.

was to the southeast toward the river; and the fact that they were exclusively devoted to manioc indicate that this species was a staple, not just a minor kitchen garden crop.

One possible reason manioc was relegated to a distant field, while maize was cultivated all around households, may be ideological. Maize is central to Maya belief systems, including creation, and perhaps it is not surprising that it also was central in cultivation. The Cerén villagers entrapped themselves in maize, both literally in milpas surrounding their households, and spiritually with their creation mythology and religious practices. Manioc is not and was not a "prestige" cultigen among the Maya, and its placement a couple hundred meters south of the Cerén village may be a direct statement to that effect. Manioc's culinary importance outstripped its mimicscale cosmological significance in ancient Cerén. Bronson (1966) cites many cultures around the world where one cultigen receives adulation and ceremony, and another, in spite of it being a staple, receives little or no special attention. That other at Cerén, manioc, was mundane, reliable, rather dull, and the tubers invisible while growing or in its underground storage.

Detailed estimation of caloric production of manioc per unit area must await excavating the beds that had yet to be harvested. Given the short time interval between harvesting/planting at Test Pits 1 and 2, it is possible that unharvested portions of the manioc field are close by. In which direction they lay is unknown. When they are discovered and excavated, quite accurate estimates of caloric productivity per unit area will be made, and compared with present day manioc productivity. More importantly for archaeology, comparisons will be made with maize productivity in the same Classic period climatic and edaphic conditions. It is likely that manioc once produced maize in harvest weight and dry weight per unit area at Cerén, but that most await pre-harvest volume measurements and comparisons.

A Cleared Area: Test Pits 3 and 4

Test Pits 3 and 4 were excavated on top of the gently sloping hill south of the Cerén site. Both encountered a Classic period surface that had been largely cleared of vegetation, and had been tramped down and smoothed by considerable foot traffic and probably by a variety of human activities. Both test pit surfaces exhibited gentle ridges that had been almost eliminated by post-agricultural activities. The fact that the tops of the ridge fronts were about 115 cm apart indicates they were not the remains of a maize milpa. We believe it had been under manioc cultivation a few years before the eruption because that "wavelength" matches the manioc fields in Test Pits 1 and 2. A few weeks, two small bushes, and one small tree were encountered as hollow spaces and cast in dental plaster. The tree (Figure 7) had epiphytes growing on its lower trunk, only a few centimeters above the ground surface.

Maize Field: Test Pits 5 and 6

Test Pits 5 and 6 were excavated on the northeastern edge of the hill to the south of the Cerén village (Figure 1). A total of 320 cm of Loma Caldera volcanic ash overlaid had to be excavated to reach the Classic period ground surface. Small-diameter cavities were encountered in clusters in Unit 3 (Miller 2002), similar to those found frequently within the Cerén village. A maize milpa was discovered in both test pits, with multiple sycamores of seeds planted together on ridges, resembling Wilken's (1971) "high-performance milpa." The average distance between ridge tops was 80 cm, and ridges averaged 12 cm in height, much smaller and closer than the manioc ridges. The maize stalks (Figure 8) were thinner than those found previously within the site, averaging 1.6 cm in diameter, indicating that these maize plants were...
Summarily and conclusions: The 2007 research season at Cerén was educational for us, in that the results directly contradicted two expectations that we had. We expected that the agricultural productivity per unit area would diminish with distance from the village, and that turning out not to be the case. And we expected to find no maize outside the village; it was a surprise to find manioc, and particularly in such a formal planting system that indicates it was a staple crop.

Manioc cultivation at Cerén, El Salvador

RESUMEN
La temporada de investigación de Cerén en 2007 es educativa para nosotros, es que los resultados contradicen dos expectativas que teníamos.

Esos resultados indican que la productividad agrícola por unidad de área menor a medida que se aleja de la distancia del pueblo y eso resulta ser cierto. No esperábamos encontrar yuca (Manihot esculenta) fuera del paraje principal. La lluvia daba una buena ayuda en la jardinería de dos o tres meses a la semana.思我们一起在村子里种植了玉米，而且特别在那些靠近小溪的地方种植了玉米。

Los resultados muestran que la productividad agrícola disminuyó con la distancia al pueblo y eso resultó ser cierto. No esperábamos encontrar yuca (Manihot esculenta) fuera del paraje principal. La lluvia daba una buena ayuda en la jardinería de dos o tres meses a la semana.思我们一起在村子里种植了玉米，而且特别在那些靠近小溪的地方种植了玉米。

Los resultados muestran que la productividad agrícola disminuyó con la distancia al pueblo y eso resultó ser cierto. No esperábamos encontrar yuca (Manihot esculenta) fuera del paraje principal. La lluvia daba una buena ayuda en la jardinería de dos o tres meses a la semana.思我们一起在村子里种植了玉米，而且特别在那些靠近小溪的地方种植了玉米。

Los resultados muestran que la productividad agrícola disminuyó con la distancia al pueblo y eso resultó ser cierto. No esperábamos encontrar yuca (Manihot esculenta) fuera del paraje principal. La lluvia daba una buena ayuda en la jardinería de dos o tres meses a la semana.思我们一起在村子里种植了玉米，而且特别在那些靠近小溪的地方种植了玉米。