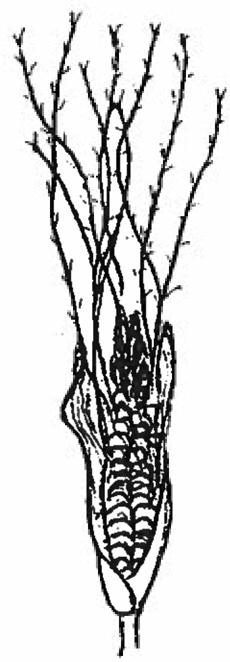
UPDATE ON MAIZE

by

Philleo Nash and R. Joseph Dent



The National Colonial Farm

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THE ACCOKEEK FOUNDATION

UPDATE ON MAIZE

A REPORT TO THE ACCOKEEK FOUNDATION

by

Philleo Nash and R. Joseph Dent

May 12, 1978

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FORWORD

"Update on Maize" by Philleo Nash and R. Joseph Dent expands our knowledge about the archeological evidence for corn's (*Zea mays*) place of origin. Professor Nash and Mr. Dent note that there are two schools of scholarly thought about the locale for the derivation of *Zea mays*: the Mesoamerican school and the South American school. This paper offers new evidence that corn as a distinct species was being grown in the Andean region much earlier than previously believed. In conclusion, the authors call for further investigation into the origins of this important plant.

This paper offers new horizons for the study of the origins of corn. Professor Nash and Mr. Dent have followed the paths of scholarly inquiry which were blazed by Henry A. Wallace in *Corn and Corn-growing* and Wallace and William L. Brown in *Corn and Its Early Fathers*.

David O. Percy
The National Colonial Farm

UPDATE ON MAIZE

by

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Until about 10,000 years ago, humankind everywhere on earth subsisted by the collection of wild food. The universal need for the sources of biochemical energy were met by the pursuit of large and small game animals; the harvest of fruits, berries, nuts and seeds; and the catch of all the products of the seas, lakes and streams. Processing these foods by the application of heat in various forms is an old human trait, older than our own species; but sowing, planting, and cultivating are not old.

The change in human behavior that accompanied the domestication of plants and animals is so great that it is often referred to as the "agricultural revolution." In the older terminology, derived from European prehistory specialists, and premised on a theory of unilineal cultural evolution, the transition from collecting to farming is called the "Neolithic." New World Archeology has brought with it the need for more descriptive terminology and early agriculture in the Americas is called the "Formative." But in both the Old World and the New, the revolution in subsistence technology in the largest sense was an adaptation to the change in world climate that occured as the weather warmed, the ice sheets retreated toward the poles and into the higher mountain elevations; and the plants and animals that were the outcome of a million years of genetie and behavioral modification gave way to and were replaced by new forms and new ways of life.

The more efficient use of energy represented by even the earliest forms of agriculture, made possible the establishment of permanent villages, the specialization of labor, the formation of organized governments, writing, and organized codes of behavior. In its more complex form -- the city-state -- the village and its agricultural base are the ancestors of all complex societies, including our own; but also including the Indian, Chinese, Aztec, Mayan and Inca cultures. The latter three exist archeologically, historiographically and as admixtures to contemporary native American cultures because of the Spanish conquest. Such city-states have existed for only about 3500 years and were superseded by nation-states with colonies at about the time of the industrial revolution.

Still, today, as colonies become independent nation-states in their own right, the world of the former colonies outside their capitals consists of villages different only in detail from those of the Formative (or Neolithic) of 10,000 years ago. Throughout Latin America, but also in Africa and some parts of Asia, the Third-world villagers will base their subsistence in part on a plant that was originally indigenous only to the New World. Today it is the product of genetic manipulation and agronomic management that is the most sophisticated of any world crop. But this has been true for a long time; for it now appears as a result of recent archeological researches in South America that two sub-varieties of corn (Zea mays) had been separated and were being managed side-by-side for appropriate uses more than 4000 years ago. Since these researches and attendant genetic implications have led to controversy, with two schools of thought and their allies ready to fight it out in the learned journals, it might be of interest to sketch the state of the art as seen by each side.

THE VALLEY OF TEHUACÁN: THE ESTABLISHMENT VIEW

Maize is unique among the world's food crops in that it has no obvious wild living ancestor. It does, however, have living relatives in a wild grass, _teosinte_ (its name in the language of the Aztecs) and a related wild plant _Tripsacum_. _Teosinte_ has long been accepted as the most likely descendant of a common forebear of maize, so it is quite natural that the search for archeological maize should be centered in those parts of the New World where this wild grass can be found today and climatic conditions may fairly be presumed to have changed little. Since _teosinte_ has never been reported south or east of Honduras, the tendency has been to rule out both the Tropical Lowlands of South America, the Andean highlands and coastal Peru, Ecuador, Bolivia and Colombia as possibilities.

The other consideration in designating areas for research is the presence or absence in local agricultural practises today of races of maize that may have been preserved in folk-practise when more sophisticated hybridization was obscuring the primitive characteristics. Information on these sub-varieties is available in a series of publications of the National Research Council that are not a part of this report. Suffice it to say that some of the currently popular races of maize in Mexico, Colombia and Peru are said by botanists to be "primitive," and presumably resemble the wild ancestor more than others. Archeological evidence of early maize in Ecuador yields dimensions and shapes that are within the range of currently grown varieties in the same area. (Zevallos, M., 1977).

With the distribution of the wild relatives of maize and the presence of "primitive" contemporary varieties, the archeological search became centered in arid northern Mexico. Between 1961 and 1964, R.S. MacNeish and his associates excavated five caves in the Tehuacán Valley. (MacNeish, 1967).

Preliminary excavation at Coxtcatlan Cave yielded primitive cobs with radioactive carbon dates of approximately 3500 B.C. Following this successful preliminary work it was decided to attempt a complete archeological column from the earliest trace of occupation up to the Spanish conquest. Thanks to extensive radiocarbon dating, no period of as much as 500 years was left without a date. Much cross-dating with other sites was also possible.

Generally speaking, MacNeish's column showed the history of cultural change over a span of more than 7500 years, beginning with evidence of cave occupation by hunters, and collectors. The first hints of plant cultivation showed up between 6500 and 5000 B.C. Between 5000 and 3500 B.C. the caves were occupied by plant collectors, but there were firm indications of maize, beans and squash cultivation, plus chili peppers.

By 3500-2300 B.C. some people were living in pit-houses on river terraces, and cultivated foods were making up 20% of their diet. First evidence of the domestic dog appears at this time.

The period between 2300 and 1500 B.C. is not as well documented as the rest of the column, being known from only two cave occupations, but crude, crumbly pottery that is among the earliest known from Mesoamerica is distinctive of the sites.

Between 1500 and 900 B.C. the people of Tehuacán Valley were subsistence farmers living in wattle-and-daub villages on the flood plains. Their crops included maize, beans, squash, chilis, amaranth, avocados, and cotton.

Between 900 and 200 B.C., there is evidence of irrigated agriculture, improved races of maize and other crops. Small farming communities had become related to larger centers, presumed to be ceremonial. Between 100 B.C. and 700 A.D. the farmers of Tehuacán regularly used irrigation, had domesticated nuts, guavas and turkeys; and lived in hamlets adjacent to large hill-top centers with stone pyramids, plazas, ball-courts and other structures associated with the priest-king complex of later Mexico.

Between A.D. 700 and the arrival of the Spanish in 1540, the Valley was made up of towns and hamlets surrounding urban centers, often fortified, and often the sites of towns of latter-day Mexico. City-states are presumed to have existed and there is clear indication of an economy based on irrigated agriculture, trade, salt production, the processing of cotton and the manufacture of stone implements. The hieroglyphic system in use at the time of the conquest was developed during this period.

This large-scale, remarkable archeological project was envisioned by MacNeish and funded by the Rockefeller Foundation and the National Science Foundation.

Among many other matters, it made possible the careful analysis of the maize sequences, for very large numbers of fragments were found. These have been analyzed in depth by Paul C. Mangelsdorf, a geneticist, and Walton C. Galinat, a botanist, as well as by MacNeish. (Mangelsdorf, 1967). Some idea of the scale of this part of the project may be obtained from a description of the specimens.

In all, 24,186 specimens of maize were found in the five caves. More than half were intact or nearly intact cobs. An additional 3,941 identified cob fragments were located. Among the remaining specimens are all parts of the maize plant, including roots, stalk, leaf and leave sheaths, inner husks, prophylls, shanks, tassel fragments, husk systems, midribs, and kernels. There were also quids including 83 chewed stalks or leaves and 140 chewed husks!

The conclusions of Mangelsdorf et. al. with respect to the origins of maize have come to be the best accepted view, but not by some of the South Americans (as we shall see later.) In summary, the earliest cobs found, dated around 5000 B.C., are regarded on botanical grounds, as wild maize. There are six reasons for this judgment:

1. The cobs are remarkably uniform in size and other characteristics, which is generally true of wild species as against cultigens.

2. The cobs have fragile parts similar to those of wild grasses, which provide a means of dispersing the seed. Modern maize lacks this facility.

3. The glumes (empty bracts) are long and must have partially enclosed the kernels as they do in wild grasses.

4. There are suitable sites in the valley well adapted to annual grasses, shunned by cacti and leguminous shrubs.

5. There is no firm evidence that agriculture had become well established in this archeological phase.

6. In the succeeding phase, agriculture is definitely established and the maize is larger and more variable than the earliest.

The conclusion to be drawn from this and from other lines of reasoning is that the ancestor of maize is maize. The difficulty with this conclusion is that the wild ancestor, if there is one, is only known archeologically. There is no living ancestor, only close relatives.

This being the case, one of the experimental ways of discovering (more accurately uncovering) the ancestor is to hybridize the wild relatives with some of the numerous races of modern maize which have been modified and adapted to climates in all parts of the world. Mangelsdorf conducted a series of such experiments and reported on them some years ago. (Mangelsdorf, 1958). He began by pointing out that fossil maize pollen had been found far below the surface of present-day Mexico City, dated to 80,000 years ago, thus leaving "little doubt" that the "ancestor of corn is corn" not one of its two American relatives, teosinte or Tripsacum. Illustrations of teosinte (Euchlaena mexicana) and Tripsacum (Tripsacum dactyloides) may be seen in Hitchcock, 1971, pp. 791 and 793. The common name of Tripsacum is "gamagrass."

Unfortunately, the excavations of MacNeish did not yield living seeds. Hence, it was impossible to work forward to modern corn. The only recourse was to work backward, combining the primitive characteristics still occuring in living varieties to reconstruct the primitive corn. The difficulty with this procedure is that its outcome depends entirely on the correctness of the assumptions about the putative ancestor. From an examination of the maize fragments obtained by excavation, Mangelsdorf concluded that primitive corn was both a popcorn with small hard kernels and a pod corn, the latter is a variety in which each kernel is enveloped in the elongate glumes. (Hitchcock, 1971, p. 794.) Having crossed the numerous varieties of popcorn with pod corn from South America, Mangelsdorf described the resulting plant.

1. Instead of having one stalk they have several and in this respect resemble the majority of wild grasses.

2. The plants are short and are accompanied by the development of a terminal inflorescence which bears both male and female flowers at the base of the same tassel branches.

3. These branches are quite brittle when mature and break apart easily. They thus provide one of the most primitive characteristics which cultivated corn lacks: a mechanism for the dispersal of the seeds.

There are some serious difficulties with this conclusion. Apparently no one solution based only on the evidence from Mexico is going to be difficulty-free. The pollen of 80,000 years ago would seem to be conclusive in itself. But why, then, no living plants except the existing cultigens. Must we assume that the ancestor lived from 80,000 until 7500 B.C. and then disappeared from the earth leaving no traces? It would seem that not enough new has been learned to justify the scale of the project, and that we must await new or additional information.

One such source which departs substantially from tradition has been available since 1962, and has recently been revived and re-emphasized.

VALDIVIA CULTURE IN COASTAL ECUADOR: THE SOUTH AMERICAN VIEW

The conventional view of culture origins in the New World stems from interest in and greater knowledge of the highlands regions; in South America, the Andes of Peru with extensions into Bolivia to the south and Ecuador to the north. The development of a complex society, the Inca Empire, functioning well at the time of conquest, but quickly destroyed, led scholars to look to complex analogues elsewhere in terms of origins, hence to Mesoamerica. This was true in spite of the importance to world civilization of such indigenous South American plants as potatoes, peanuts, cotton, and manioc.

In Ecuador researchers found the most northerly extension of the Inca, side-by-side with heavy reliance on specialized races of maize which have adapted to the high altitudes and also to the coastal plain. With a too-ready willingness to look toward Mesoamerica, North American scholars have overlooked data available since 1962 showing the existence of well-developed maize technology in the coastal areas of Ecuador going back to 3000 B.C.

This is a fascinating story of collaboration between young North American anthropologists and a small group of Ecuadorian scholars. In

1941 the Field Museum of Natural History sent Donald Collier and John Murra to survey the southern Ecuadorian highlands. Collier is now a Curator at Field; Murra is a Professor at Cornell. They excavated a site, Cerro Narrío, which contained clues to the antiquity of maize agriculture in Ecuador, but in the absence of accurate dating methods (radiocarbon dating was an offshoot of World War II research) they underestimated the age of the archeological culture. In the course of the next twenty years other North and South American scholars collaborated and gradually a picture emerged of a well established culture going back to as much as 3500 B.C. with noticeable similarities to horizons in Mesoamerica and Peru.

But, in 1961, an Ecuadorian scholar, Carlos Zevallos Menéndez excavated at San Pablo on the Ecuadorian coast. His researches were made known to Americanists in 1962 (Zevallos M., 1977, p. 385) and were discussed at length in a monograph published in 1971. (Zevallos M., 1971). Nevertheless these researches were ignored or denied validity but have recently received publicity through the efforts of Lathrap, Collier and their associates. The exhibit, "Ancient Ecuador," Ecuador's contribution to the Bicentennial, was organized to make the Ecuadorian Formative better known, but also to remedy the inattention to Zevallos Menéndez. He found a well-developed, agricultural, pottery-making complex with an antiquity exceeding that of Mesoamerica and Peru by some 2000 years. His most spectacular find was a fragment of pottery in which the potter had accidentally incorporated a kernel of maize when the paste was still soft. When it was fired, the kernel became carbonized. The oil-bearing portions of the kernel were vaporized but left their shape in the paste intaglio. The harder portions remained as carbon particles available by modern laboratory techniques for accurate dating. The date of this kernel supported by other particles from the same and other sites is well established at around 2000 B.C.

The San Pablo kernel does not stand alone, however. Seven variables from a large number of sites in Guayas Province in Ecuador support the argument.

The seven are: (i) the San Pablo kernel itself; (ii) representations of cobs of Zea mays on pottery of the era; (iii) decorative stampings of the rims of Valdivia III pots made by pressing kernels of maize into the soft clay; (iv) large quantities of hand grinding mills (the mano and metate) still in use for grinding maize in parts of the new World; (v) the presence of quantities of a small marine snail (Cerithidia pulchra). It is not eaten by the local folk today and is deemed inedible by the archeologists, but would be suitable for the production of lime, essential even today for the softening of the maize kernels in the intermediate process of making masa, the partially cooked, lime-soaked corn kernel; (vi) bell-shaped pits suitable for the large-scale storage of maize in the Ecuadorian coastal climate; and (vii) charred cobs of maize from Cerro Narrío itself in context well before 2000 B.C.

In the beginning, the importance of the San Pablo kernel was not appreciated. For more than a decade Zevallos Menéndez stood out as the only protagonist of early agriculture in Ecuador. The San Pablo kernel had few friends except for Collier, Lathrap and Murra. The renowned Smithsonian, which published much of the early work in South America, published a closely reasoned argument by Evans and Meggers which held that the sophisticated pottery of the Ecuadorian Formative was in fact evidence of culture contact with Japan!

In 1974 Donald Lathrap excavated the site of Real Alto in coastal Ecuador. Among his staff was an undergraduate student from the University Learning Center, American University, David Card. Lathrap's findings were well summarized in the catalogue of the aforementioned exhibit and have recently been brought up to date to include the results of the 1974 excavations.

It appears that Real Alto was occupied for at least 1000 years. Eighty domestic structures (houses) were excavated out of the thousands that were in use during the long history of settlement. The village had a northern and a southern precinct, separated by mounds on the top of which were structures that appeared to be prototypes of the much later Mesoamerican temples. In a very early level, spindle-whorls of sandstone were found, suggesting the cultivation of cotton nearly 5000 years ago.

Ceramic fragments in quantity also appeared, their form suggesting the bottle-gourd. This is a cultivated plant of new world origin which is believed to make the transition from pre-pottery to ceramic representation. (In other words, before they made pottery, the Valdivians grew and used gourds for bottles. Later, they made pottery imitations of gourds, using the naturalistic designs.)

Of possibly greater significance, were numerous pottery fragments with impressed maize kernel designs. The frequency of manos and metate fragments was very high, at least one per six square meters of excavation. They also seem to have been dealt with ceremonially. Thus, some were used as the lining of a burial. Others were broken and placed in heaps, like an offering. Zevallos M. had previously reported finding the metates broken and placed upside down.

Large quantities of deer bones, of selected fish bones and of selected mollusk shells suggest, respectively, the association of deer with maize patches; of particular rather than generalized selection of fish for food; and of even more extensive use of shell fish for lime production.

The wear pattern of the molars on the skeletons examined also indicate large quantities of abrasive foods in the Real Alto diet, even including the dogs. (Today, dogs in the Ecuadorian villages are fed the remains of tortillas and other maize foods which contain the remaining grains of sand from the grinding stone and result in excessive molar wear in humans and pets alike.)

In summary, the theories of Carolos Zevallos Menéndez with respect to the antiquity of maize and agricultural villagers in Ecuador are supported by archeological research, some as recent as reports stemming from investigation made in the summer of 1974. They are not as yet integrated with theories of the domestication of maize in Mesoamerica. Future theories must take into account the existence of agricultural communities based on maize in Ecuador with a calibrated antiquity up to 3550 B.C. and sophisticated pottery and maize technology at 2920 B.C. The necessary implication is that there was some kind of genetic meddling several thousand years earlier.

COMMENTARY ON THE ORIGIN OF MAIZE

In the Tigris-Euphrates Basin, where the cereal staple wheat was domesticated first, on which the nation-states of the Western World were based up to the importation of maize from the New World, a wild grass, emmer can be found on the hillsides, growing more or less as it did 10,000 years ago. If, by some genetic cataclysm our current races of wheat should self-destruct, their descendants could be reproduced in quick biological time.

Not so, maize. Unaided by human hands, maize would quickly disappear. Its ancestry is a matter of dispute. There are no massive stands of a putative ancestor which could be genetically manipulated to restore the world supply of contemporary varieties. Moreover, the experts who might be called upon to do the work would end up in violent disagreement.

The work of the justly famous maize research station in Mexico does not appear to be helpful at present, for its thrust has been in the directly opposite direction; namely to manipulate the genetic structure of maize to meet environmental conditions around the world.

The geneticist, George Beadle, Nobel Laureate and former President of the University of Chicago, is quoted from remarks he made in a lecture presented at the Agronomy School Seminar at the University of Illinois, Urbana, March 26, 1974. "The earliest known cultivated corn which appeared in the Tehuacán valley, in Mexico, shows a level of genetic modification which could only be understood in terms of at least 1000-2000 years of prior development under primitive cultivation. Therefor, the experimental level of agriculture in the New World had to extend back into a time range of 7000-8000 B.C." (Lathrap, 1975.)

The "Friends of the San Pablo Kernel", indignant over the neglect of everything South American, lean toward the possibility of domestication in the tropical lowlands east of the Andes, in the Amazon basin. Unfortunately, they too lack a wild variant, and are supported only by some early travelers' descriptions of a teosinte-like grass. They, too, are thus driven into speculation about the origins of maize.

Nevertheless, the demonstrated presence of a fully developed Formative complex in Coastal Ecuador 1000 years earlier than anywhere in Mesoamerica or Peru has created new rules for the ball game. The similarity of the

Valdivia maize to present day Ecuadorian strains casts doubts on Mangelsdorf's premises. The possibility of a straight line of descent from teosinte to the present day races of maize in use by the Indians of Central and South America can no longer be ruled out. Further archeological investigations will also be needed and will be forthcoming. Lathrap has already left Urbana for another season's work in Ecuador.

What is not being done, it appears, is breeding experimentation based on a different set of premises than those of Mangelsdorf. It is not clear today, if it ever was, that "maize is the ancestor of maize." The genetics of teosinte, Tripsacum and maize, both archeological and contemporary need to be investigated *de novo*.

One of the by-products of the discovery of the New World was the enrichment of the rest of the earth's domesticated plant population. The major ones are not numerous in terms of present world food and fiber production, but they deserve some of the attention that has been given so far mainly to maize. They include the following:

Tropical Lowlands Manioc, peanuts, pineapple, tobacco, sweet potato and New World yam, bottle gourd.

Andean Highlands Potato, quinoa, chili pepper, squash, and cotton.

Mesoamerica Maize, beans, squash and chili peppers; amaranth, avocado and cotton.

A bibliography of works relating to the origin of maize, is a part of this report. Similar bibliographies on other domesticated plants indigenous to the Americas could usefully be prepared. This could be done concurrently with continued perusal of the archeological and genetic literature to keep abreast of the rapidly expanding work on the Formative.

Aside from library research there are urgent needs. They may currently be met at various research stations. This library survey of the problem does not purport to know that. It should be done. They include the following:

1) Preservation of living specimens of primitive races of maize;

2) Preservation of living specimens of the other major New World cultigens in their primitive forms;

3) Breeding experimentation and other genetic research to update Mangelsdorf.

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APPENDIX

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