RACES OF MAIZE IN PERU

Alexander Grobman
Wilfredo Salhuana
Ricardo Sevilla

in collaboration with

Paul C. Mangelsdorf

NATIONAL ACADEMY OF SCIENCES—
NATIONAL RESEARCH COUNCIL

Publication 915

Funds were provided for this publication by a contract between the National Academy of Sciences—National Research Council and The Institute of Inter-American Affairs of the International Cooperation Administration. The grant was made for the work of the Committee on Preservation of Indigenous Strains of Maize, under the Agricultural Board.

The AGRICULTURAL BOARD, a part of the Division of Biology and Agriculture of the National Academy of Sciences—National Research Council, studies and reports on scientific problems of agriculture in relation to the national economy. Financial support for the meetings and publications of the Board is derived primarily from the Agricultural Research Institute, which is an organization composed of representatives of industry, trade organizations, academic institutions, and governmental agencies concerned with agriculture. Members of the Agricultural Board and of its committees serve without compensation beyond their actual expenses. Funds for the work of the Agricultural Board are received and administered by the Academy.

RACES OF MAIZE IN PERU
THEIR ORIGINS, EVOLUTION AND CLASSIFICATION

Alexander Grobman, Wilfredo Salhuana and Ricardo Sevilla
in collaboration with
Paul C. Mangelsdorf

Publication 915
NATIONAL ACADEMY OF SCIENCES—
NATIONAL RESEARCH COUNCIL
Washington, D. C.
1961

Other publications in this series

RACES OF MAIZE IN CUBA
William H. Hatheway
NAS–NRC publication 453 1957 Price $1.50

RACES OF MAIZE IN COLOMBIA
L. M. Roberts, U. J. Grant, Ricardo Ramírez E., W. H. Hatheway, and D. L. Smith *in collaboration with* Paul C. Mangelsdorf
NAS–NRC publication 510 1957 Price $1.50

RACES OF MAIZE IN CENTRAL AMERICA
E. J. Wellhausen, Alejandro Fuentes O., and Antonio Hernandez Corzo *in collaboration with* Paul C. Mangelsdorf
NAS–NRC publication 511 1957 Price $1.50

RACES OF MAIZE IN BRAZIL AND OTHER EASTERN SOUTH AMERICAN COUNTRIES
F. G. Brieger, J. T. A. Gurgel, E. Paterniani, A. Blumenschein, and M. R. Alleoni
NAS–NRC publication 593 1958 Price $2.00

RACES OF MAIZE IN BOLIVIA
Ricardo Ramírez E., D. H. Timothy, Efráin Díaz B., and U. J. Grant *in collaboration with* G. Edward Nicholson Calle, Edgar Anderson, and William L. Brown
NAS–NRC publication 747 1960 Price $1.50

RACES OF MAIZE IN THE WEST INDIES
William L. Brown
NAS–NRC Publication 792 1960 Price $1.50

RACES OF MAIZE IN CHILE
David H. Timothy, Bertulfo Peña V., Ricardo Ramírez E. *in collaboration with* William L. Brown and Edgar Anderson
NAS–NRC Publication 847 1961 Price $1.50

Previously published by the Bussey Institute, Harvard University, in 1952
RACES OF MAIZE IN MEXICO
E. J. Wellhausen, L. M. Roberts, and E. Hernandez X. *in collaboration with* Paul C. Mangelsdorf
Free with purchase of above publications

Library of Congress Catalog Card Number: 61-60080

Price $2.50

CONTENTS

ACKNOWLEDGMENTS

The investigations on which the present monograph is based, because of their wide scope and nature, could not have been carried on without the active participation of many individuals. Whatever merits it may have are due in great part to their enthusiasm and coordinated efforts. The authors alone, however, wish to assume responsibility for any shortcomings.

We are much indebted to our colleagues, the staff members of the Cooperative Program for Maize Research and of the Universidad Agraria, La Molina, Peru, particularly to Ing. Ulises Moreno, who carried out the cytological work involved in this project, and to Ing. Alfonso Cerrate, Ing. Antonio Manrique, Ing. Miguel Paulette, Ing. Federico Scheuch, Ing. Julio Lugo, and Ing. Manuel Arca, for their help in obtaining the original maize collections and their assistance in growing them and in securing field and laboratory data.

The assistance of several field collectors, particularly of Messrs. F. and J. Pulgar Vidal, in assembling the first maize collections, is gratefully acknowledged.

We wish to express our deep appreciation for the aid rendered this study by the Departamento de Investigaciones Agropecuarias of Colombia, and the Rockefeller Foundation Agricultural Program in Colombia, represented by its former Director Dr. Lewis M. Roberts, and the Colombian Maize Center and the Maize Program Co-Directors Dr. David Timothy and Ing. Ricardo Ramirez, for making their museum ear specimens from the Andean area available for study at Medellin, Colombia, as well as for providing duplicate seed stocks from their Center for plantings in Peru. The collaboration of Mr. Victor Manuel Patiño, also of the Colombian Center, in initiating the maize collecting and in training field collectors is gratefully acknowledged.

We wish to thank especially Dr. Barbara McClintock of the Carnegie Institution, Cold Spring Harbor, N. Y., who during her two visits to Peru organized the cytological survey of the Peruvian maize races, and provided technical guidance to the cytologist engaged in this work.

The interest of archaeologists and anthropologists actively working on the Peruvian coast was manifested in making their archaeological maize material available for the present research. We are particularly indebted to Dr. Jorge Muelle, Director of the Anthropological Museum of Lima, to Mr. Rafael Larco Hoyle, Curator of the Museo Larco Herrera, and to Mr. A. Garrido of the University of La Libertad Archaeological Museum for permission to study and photograph their maize ear and pottery collections; to Dr. John Murra of Vassar College, to Dr. Dwight Wallace, formerly of the University of California, now of the University of Georgia, to Dr. Dorothy Menzell and Dr. Gary Vescelius of the Fulbright Archaeological Mission in Peru, and to Mr. Ducio Bonavia of Lima, for making available to us their recently obtained archaeological material.

We wish to express our gratiude to Dr. Margaret A. Towle, Botanical Museum, Harvard University, for permitting us to study her ethnobotanical collections from Peru, and for access to her unpublished manuscripts.

The courtesy of Dr. Joseph Tossi, Jr., of Instituto Interamericano de Ciencias Agricolas, Zona Andina, La Molina, Peru, and its Director, Dr. Carlos Madrid, in permitting the reproduction in an abridged form of the former's as yet unpublished Ecological Map of Peru (Fig. 3) is gratefully appreciated.

We are indebted to Dr. Cesar Vargas, University of Cuzco, for providing the originals of Figs. 39, 40, and 41.

The internode diagrams, distribution maps, tassel diagrams, and ear-cross-section diagrams were skillfully executed by Mr. Julio Lostao and other students at the Universidad Agraria, Peru. The photographs of the living races of maize were made from the excellent negatives prepared by Mr. Jorge Neumann.

To Miss Deyanira Reyes and to Miss Gaby Vascones we are indebted for their secretarial help in processing data at La Molina, Peru.

We are particularly grateful to the more than fifty students and staff foremen of the Cooperative Program of Maize Research, who were connected with this project, for their invaluable help in collecting, checking, tabulating and analysing much of the vast amount of data involved in this study.

The encouragement and support received from the former Director of the National School of Agriculture, Dr. Alberto Leon

and the present Rector of the Agrarian University of Peru, Ing. Javier Becerra, are greatly appreciated.

We are grateful to Ing. Benjamin Quijandria, Director of the Cooperative Program of Agricultural Research, Ministry of Agriculture, Peru, and the heads of the Regional Agricultural Services of Cuzco, Junin, and Ayacucho, for the extension of facilities and the provision of land for growing maize collections. We are also indebted to Sociedad Agricola Paramonga, Grace and Co., Estancia La Rinconada, Lima, and Mr. Manuel Orihuela, Cuzco, for making land available for this purpose.

To the National Academy of Sciences—National Research Council we are deeply grateful for providing a grant which financed this study, and for providing funds for its publication.

We wish to thank the Rockefeller Foundation Division of Agricultural Sciences for its repeated grants to collateral projects in the Cooperative Program for Corn Research at the Agrarian University of Peru, which in an incidental manner helped to support the general expenses of this particular project; and also for awarding the senior author a Fellowship for Graduate Study at Harvard University, where the manuscript was written.

Special credit is due to Dr. Albert F. Hill of the Botanical Museum of Harvard University for his patient and thorough revisions of the final drafts of this manuscript.

The seemingly endless drafts of the text, as well as the tables and figure legends for the final manuscript, were typed by Mrs. Ana M. Grobman. We are indebted to Mrs. Kathleen Powers for typing the final draft of this monograph.

RACES OF MAIZE IN PERU
THEIR ORIGINS, EVOLUTION AND CLASSIFICATION

by Alexander Grobman, Wilfredo Salhuana and
Ricardo Sevilla
in collaboration with
Paul C. Mangelsdorf[1]

INTRODUCTION

The present publication has as its primary purpose a description of the variability, racial configuration, relationships, origin, and evolution of the races of maize in Peru. A preliminary and necessary limited approach to racial classification in Peru was made by Cutler in 1946 within the context of his general treatment of the races of maize in South America. More recently, Nicholson (1958), published a brief, but accurate description of a number of the types of maize and their distribution in Peru, based on his own studies and collections from 1946 to 1950. Herrera (1941) and Macbride (1936), who translated into English the work of the former, presented a partial classification of the types of maize of the Department of Cuzco.

In spite of the general realization among students of maize of the importance of this cereal in the Peruvian area no specific attempts had been made in the past to conduct serious studies on the origin and variability of maize in this region, at least on anything like the scale to which this had been done in Mexico and Central America.

Maize collections were made by Collins about 50 years ago, and by Richey and Emerson in 1924; the latter material yielded considerable data for the genetic studies of Emerson and his students.

The most abundant collections, however, were made in the late 1920's by the Russian explorers Bukasov and Jusepsuk, par-

---

[1] The authors are respectively: Professor and Head, Associate Agronomist, and Assistant Agronomist, Cooperative Program for Maize Research, Universidad Agraria, La Molina, Lima, Peru; Professor of Botany, Harvard University, Honorary Professor, Universidad Agraria.

ticularly the latter. Their specimens, numbering 539 different samples, were housed in the Institute of Applied Botany at Leningrad, and were lost during the Second World War.

Mangelsdorf and Reeves (1939) were the first to assemble the scattered information on maize from the Peruvian region, and to establish the general relationships of Andean maize within this species.

Work on the present project started in 1952. Collection of maize in Peru was initiated under the sponsorship of the Committee on the Preservation of Indigenous Strains of Maize of the National Academy of Sciences-National Research Council of the United States of America. Funds were made available to the Agricultural Program of The Rockefeller Foundation in Colombia to finance field collections. Sr. Manuel Patiño was commissioned from Colombia as a trained collector to initiate this work. The National School of Agriculture of Peru took interest in the project and assigned members of its staff to implement its local operations. Additional support was received from the Peruvian Ministry of Agriculture.

By 1954 nearly 1300 collections, which have been later increased to 1600, were registered, and viable seed of them was kept in cold storage at La Molina, Peru. A partial duplicate of this collection is at Medellin, Colombia, in the Andean Seed Preservation Center, and a triplicate, made up of representative 15-lb. samples of each race, is being built up for storage at the U.S. Department of Agriculture National Seed Storage Laboratory at Fort Collins, Colorado.

In 1956 a direct grant was given to the National School of Agriculture of Peru by the National Academy of Sciences—National Research Council, for the purpose of studying and classifying the races of maize in Peru.

From 1954 to 1959, eleven plantings were made at the various localities listed in Table 1. Assigned to each locality were those collections originating in habitats most nearly approaching it in elevation. Three latitude areas and three altitude regions were included. Field and laboratory notes were taken on plants, tassels, and ears of each collection for permanent registration and classification.

After a preliminary classification of the races had been made in 1955 and 1956, typical collections were selected on the basis

TABLE 1. Locations and Years where Collections were Grown to Provide Data for the Present Study.*

Location	*Elevation meters above sea level*	*Region*	*Year and season grown*
Paramonga	30	Central Coast	Winter 1955
La Molina	250	Central Coast	Summer 1955
La Molina	250	Central Coast	Summer 1957
La Molina	250	Central Coast	Summer 1958
La Molina	250	Central Coast	Winter 1958
Mantaro, Junin	3200	Central Sierra	——— 1954
Mantaro, Junin	3200	Central Sierra	——— 1956
Mantaro, Junin	3200	Central Sierra	——— 1957
Mantaro, Junin	3200	Central Sierra	——— 1958
Cuzco (Kcaira	3200	South Sierra	——— 1957
and Urubamba)	2800	South Sierra	
Cuzco (idem.)	2800	South Sierra	——— 1958
Ayacucho	2300	South Sierra	——— 1959

* Seven additional plantings, not listed here, were made for seed propagation purposes.

of ear type and on being relatively true breeding to the racial type, for additional detailed studies and comparisons.

In the summer of 1958 cytological analyses of the races was initiated under Dr. Barbara McClintock's advice, training, and counsel, and continued by Ing. Ulises Moreno, who is responsible for all the cytological data presented in this publication.

The senior author had the opportunity of studying, during three weeks in 1957, museum ear specimens of duplicates of Peruvian collections, and originals of Bolivian, Ecuadorian, Chilean, Colombian, and Venezuelan collections at the Agricultural Experiment Station "Tulio Ospina" in Medellin, Colombia. This stage of the studies was important in establishing the connections and relationships of Peruvian corn races with those of neighboring countries.

Because of the wealth and excellent state of preservation of archaeological corn material from the Coast of Peru, an important part of this study concerning the evolution of corn, and the establishment of its association with modern races, was based on this archaeological material.

Actual ear specimens and pottery were made available for our study at the National Archaeological Museum of the University of San Marcos in Lima, the Museum of the University of La Libertad in Trujillo, the Larco Museum at Hacienda Chiclin,

FIG. 1. Map showing the location of the Departments and the river systems and lakes of Peru.

and several private collections. Active students of Peruvian archaeology and anthropology have provided all their newly found corn ears and plant material for study by us during the past three years.

Finally, the manuscript for this publication was written while the senior author was at Harvard University under a Fellowship of the Rockefeller Foundation. Additional use was made of museum ear specimens and archaeological material in the Harvard Botanical Museum.

GEOGRAPHY, CLIMATE AND ECONOMIC REGIONS

Peru is the third largest country in South America (next to Brasil and Argentina), with an area of over 1,350,000 square kilometers. Its boundaries are Ecuador and Colombia on the north, Brasil on the east, Bolivia on the southeast, Chile on the south and the Pacific Ocean on the west, where it has a shoreline about 1,900 kilometers in length (Fig. 1).

Its geographical location is essentially equatorial, almost reaching the Equator at the extreme northern point of Apaya Island on the Putumayo River (0° 2′S), and extending southward to 18° 21′03″. south latitude, near Concordia, on the Chilean border, a distance of about 2,080 kilometers in a straight line. The east-west distances range from a maximum of 1,258 kilometers from Punta Pariñas to the Yavari River, to a minimum of about 600 kilometers near the 8° parallel of south latitude..

The Andean ranges of mountains (or *cordilleras* as they are called in Peru) cross the country on a wide arch, parallel to the littoral, from the southeast to the north, setting the background for the highly complex physiography of Peru.

Three main natural regions are determined by the Andes; (a) the Coast (*costa*), a long and relatively narrow strip of land between the Andean Cordilleras and the Pacific Ocean; (b) the Highlands (*sierra*) including the mountains and high plateaux; and (c) the eastern Lowlands, (commonly referred to in Peru as *selva* or *montana*).

The Coast is the region extending in elevation from sea level to an altitude of 1,000 to 1,500 meters. It comprises one-eighth of the territory of Peru and one-fourth of its population. It accounts for 39 per cent of the food production of the country

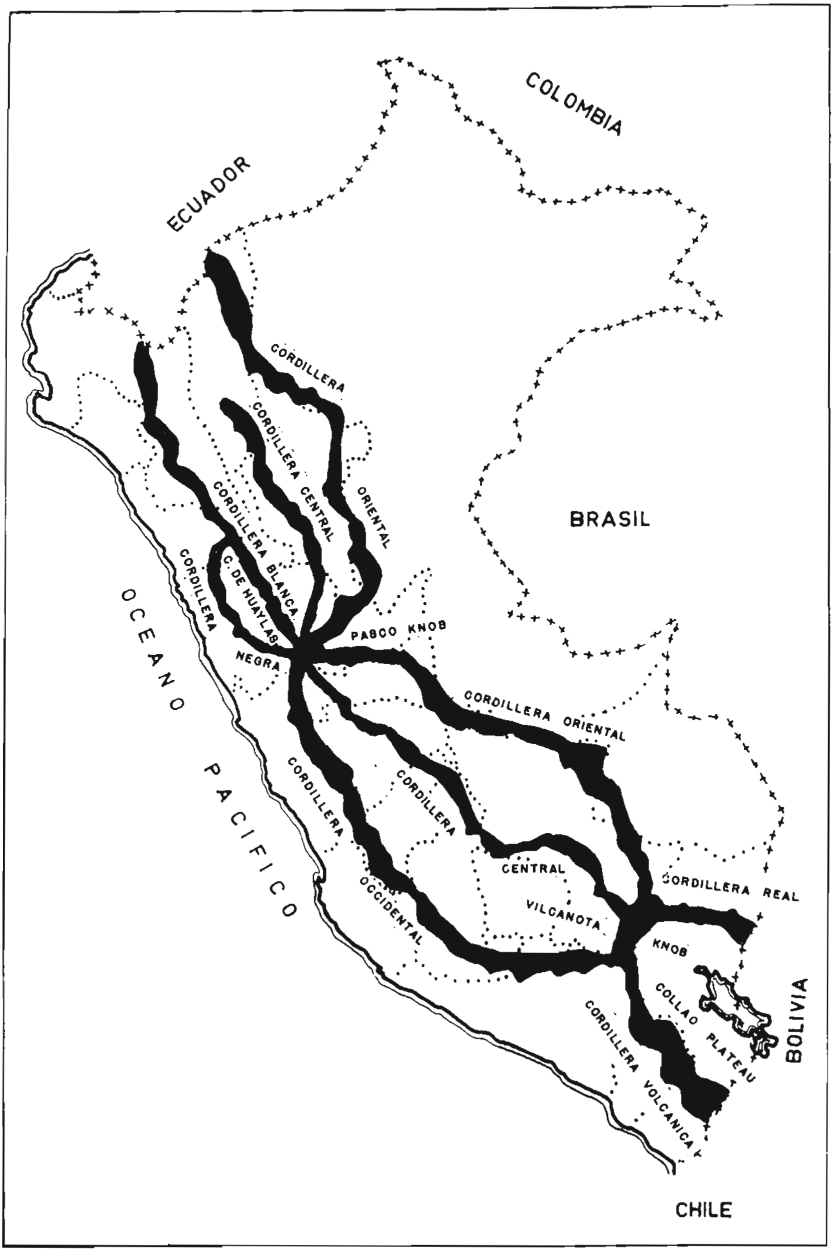


FIG. 2. Orographic map of Peru.

(Pareja-Paz Soldan, 1950). Its width varies between 80 and 180 kilometers, and only in the northern Department of Piura does it extend as far as 250 kilometers from the ocean. This area is almost wholly a desert nearly 13 million hectares in extent, only about half a million of which are under cultivation. The cultivated areas are distributed along 52 transverse valleys whose rivers originate in lagoons at the snow level of the western range of the Andes, or in small watersheds with low precipitation. Their water supply, with a few exceptions, is meager and limits the area that can be successfully cultivated in each valley. Irrigation projects are, however, fast changing the water-supply situation in many valleys of the Coast. The soils in the coastal valleys vary from sandy, to sandy loams, silt loams, and silty-clay loams, with a neutral or slightly alkaline reaction. Saline and humid soils are frequent in some valleys.

The Sierra is the region starting at about 1,500 meters above sea level on the western Andean slopes and extending along and across the entire Andean system to an altitude of about 1,000 meters on the eastern slopes. It comprises three-eighths of the territory of Peru, five-eighths of its population, and accounts for 57 per cent of its food production (Pareja-Paz Soldan, 1950).

An understanding of the orography of the Andean system of mountains is essential to the visualization of the physiography of the Sierra. The Andean mountain system proceeding from south to north is as follows (Fig. 2). Two ranges of mountains enter from Chile and Bolivia near the 18° and 16° parallels; these are the *Cordillera Volcanica* and *Cordillera Real,* which converge to form the *Vilcanota Knob,* south of Cuzco. Three *Cordilleras, Oriental, Central* and *Occidental,* surge northward from the *Vilcanota Knob,* meeting at the *Pasco Knob* in central Peru. Three new *Cordilleras, Oriental, Central* and *Occidental* proceed from this point northward until they join in the *Loja Knob* in Ecuador. These three *knobs* divide the Andes into three sections: Meridional, Central, and Septentrional, and with the cordilleras they form the major basins and inter-Andean valleys of the Urubamba, Apurimac, Mantaro, Marañon and Huallaga, and enclose the high plateau of Collao with Lake Titicaca. (Pareja-Paz Soldan, 1950).

The Occidental Cordillera is the axis dividing the Pacific and Atlantic watersheds. This range is the roughest and includes the higher peaks in Peru, which are located in the Department of Ancash (Huascaran, the highest mountain, reaches an elevation of 6,767 meters). In Ancash, also, it divides into two subranges separated by the Santa valley or *Callejon de Huaylas.*

The Oriental Cordillera is the oldest. While in Ecuador this Andean range falls almost vertically to the plains, in Peru and Bolivia secondary branches project into the jungle, forming valley and canyons.

The eastern Lowlands or Selva region starts on the eastern Andean slopes at 1,000 meters elevation and proceeds downwards and eastward. This region is the largest, with 550,000 square kilometers, or five-eighths of the territory, but only one-eighth of the population (Pareja-Paz Soldan, 1950).

The climate of the various Peruvian regions is regulated by three main factors: (a) the tropical location, (b) the Andean system of mountains, and (c) the Humboldt or Peruvian Current in the Pacific Ocean. A purely tropical climate, typical of its position, prevails in Peru only in regions where the other two factors do not exert their influence, such as in the northernmost extreme of the Coast, and in the Selva.

The climate of the Coast is mild, with high relative humidity and very low precipitation. The Humboldt Current running parallel to the Coast, lowers the temperature of the ocean and surrounding air and produces condensation of moisture into a low-hanging canopy of clouds, at an altitude of 300 to 900 meters above sea level. This canopy may extend 200 kilometers into the sea and about 20-30 kilometers inland, over a period of several months, usually from May to November, lowering the light intensity to one fourth of full sunlight at ground level, and maintaining a relative atmospheric humidity of around 80 per cent. Precipitation in the form of drizzles or condensation in the hilly areas may run up to 150 to 300 mms. per year, while in other areas of the Coast it ranges between 0.5 and 50 mms. per year. The average mean temperature in Lima is 19.5° C, with a summer mean of 18° to 24° C (December to April) and a winter mean that varies from 12° to 15°, for the season represented by the remaining months of the year. (Pareja-Paz Soldan, 1950).

The climate of the Sierra is most varied. Half of the climates of the world may be found at different latitudes and altitudes in the Peruvian Andes (Bowman, 1916). At 3,200 m. in the Mantaro valley the frost-free growing season averages 227 days, considering a probability lower than five per cent of the occurrence of 0° C temperatures or lower at the extreme dates of the growing season. Such a growing period is comparable in length to that of Georgia or Arkansas in the United States (Olave and Grobman, unpublished).

Temperature variations from day to night in the Sierra may be considerable, particularly during the months of May to September, and may reach extremes of 27° C or more depending on the altitude. At levels below 1,000 m. in some inter-Andean valleys, high temperatures of 25° to 30° C may prevail during the daytime, with little change at night. In Table 2 average monthly temperatures are shown for selected locations at several latitudes and altitudes, showing how these factors interact in conditioning the magnitude of this climatic factor.

Heavier precipitation than on the Coast starts above 2,000 meters in the South, above 1,000 meters in the Central areas and above 400 meters in the North. There is a rainy season in the Sierra from June to September. The total amount of rainfall per year for some of the localities listed in Table 2 from south to north, follows: Puno 963 mm., Cuzco 804 mm., Jauja 497 mm., Cajamarca 1,144 mm. (Knoch, *vide* Weberbauer, 1945).

The lowlands of the Selva, descending from the eastern Andean ranges and spur slopes into the Amazon Basin plains, exhibit a climatic transition. On the mountain slopes the climate is rather mild, subtropical, with a medium precipitation level, while on the plains it is sweltering, torrid, with a heavy rainfall, which varies from 1.3 to 2.0 meters per year.

Eight altitudinal climatic regions have long been recognized in Peru, and they are today deeply incorporated into the com-

TABLE 2. Average Monthly Temperatures in Degrees Centigrade at Various Elevations in the Sierra of Peru

Location	*Latitude S*	*Altitude in meters*	*Warmer month*	*Colder month*	*Annual*	*Variation*
Puno	15°50′	3822	Nov. 10.3	Jul. 5.8	8.3	4.5
Cuzco	13°27′	3380	Nov. 12.1	Jul. 8.3	10.7	3.8
Juaja	12° 4′	3450	Mar. 12.1	Jun. 9.2	10.9	2.9
Cajamarca	7°10′	2810	Dec. 15.9	Jun. 11.9	14.6	4.0
Arequipa	16°22′	2451	Sept. 14.4	Jul. 13.1	13.8	1.3
La Joya	16°46′	1262	Feb. 18.7	Jul. 15.3	16.9	3.4

mon knowledge of the Andean Indian. Pulgar Vidal (1946) has correlated these climatic regions with definite altitudinal levels. We have found this classification convenient for purposes of zonal distributions of maize races and we have adopted it for the characterization of altitudinal adaptation zones. Such a classification of climatic regions with their included ecological formations follows:

1. *Chala* is the region corresponding to the Coast. The name means stalks of corn in the Quechua language. This area extends from sea level to 500 meters elevation. Its climate has been described above as typical for the Coast. Ecologically it corresponds to tropical and subtropical deserts.

2. *Yunga* is the region corresponding to the warm and dry lower elevations of the Andes. In Quechua it means warm valley. *The Maritime Yunga* is the region of the Western Cordillera, between elevations of 500 to 2,500 meters. It is physiographically characterized by irrigated valleys, canyons, and ravines, with a warm, dry climate. The coastal fogs reach its lower limits. This region has been named by Weberbauer (1936), the Inner Coastal Belt. Ecologically, it comprises mountain desert and dry spiny shrub formations; its native woody vegetation is made up chiefly of algarrobo (*Prosopis juliflora* (Sw.) DC.), *Capparis spp.* and groves of *Schinus molle* L. bordering the rivers. Other species, predominantly *Cactaceae*, are found on the hill slopes outside the irrigated areas.

The *Fluvial Yunga* is the corresponding area on the eastern slopes of the Andes and inter-Andean valleys between elevations of 1,000 and 2,500 meters. This region is temperate–subtropical, with a dry climate and torrential summer rains. Its natural vegetation is made up of shrubwoods and bush forest of an evergreen type, with hard, coriaceous foliage. Except for certain valleys, there seems to be a floristic disunity with the *Maritime Yunga* in middle and southern Peru (Weberbauer, 1936).

3. *Quechua* is the region between 2,500 and 3,500 meters above sea level. Its climate is mild, with great temperature differences between day and night, and with a marked rainy season. This area has the largest human population in Peru, and is characterized by its maize agriculture. Important trees and shrubs of this region are *Alnus jorullensis* H. B. K., *Schinus molle* L., *Piqueria peruviana* (Gmel.) Robinson, *Cantua pyrifolia*

Juss., *Berberis commutata* Eichl., and *Caesalpinia tinctoria* (H. B. K.) Benth. (Weberbauer, 1936, 1945; Pulgar Vidal, 1946).

4. *Suni* is the region of the higher elevations ranging from 3,500 to 4,100 meters above sea level. In northern Peru the Suni region is called *Jalca.* The Bombon plain in central Peru, the Collao plateau with Lake Titicaca, and the upper western and eastern slopes of the Andes are included in this region. Its climate is cold and dry. Characteristic natural shrubby vegetation of the *Suni* include quinuar (*Polylepis racemosa* Ruiz and Pav.), several species of *Buddleia,* cantuta (*Cantua buxifolia* Juss.) and tarhui (*Lupinus* spp.). Cultivated plants of this region are potatoes, quinoa *(Chenopodium Quinoa* Willd), olluco *(Ullucus tuberosus* Lozano), etc. (Pulgar Vidal, 1946).

5. *Puna* is the very cold region located above 4,100 meters. It is characterized by low-growing, herbaceous tundra vegetation, forming vast grasslands, where such species as *Festuca dolichophylla* Presl., *Festuca rigescens* (Presl) Kunth, *Calamagrostis rigida* (H.B.K.) Trin. ex Steud., *Calamagrostis rigescens* (Presl) Scribn., *Calamagrostis vicunarum* (Wedd.) Pilger, and species of *Bromus, Dissanthelium,* and other grass genera are found.

6. *Janca* is the glacial region of the highest peaks of the Andes, with permanent snow. Ecologically it corresponds to alpine and nival regions.

7. *Rupa-Rupa* is the high jungle region, or *Selva Alta,* from 400 to 1,000 meters above sea level, below the *Fluvial Yunga.* It is hot and humid, with a rainy season between November and May. Several ecological formations may be recognized in the *Rupa-Rupa:* Humid low-mountain, rainy low-mountain, humid subtropical and rainy subtropical forests, brush or thorny tropical savannas, and low-humid-ground grasslands or *pajonales.*

8. *Amazonia* is the low jungle region, or *Selva Baja.* It is the vast plain extending below and beyond the last spurs of the eastern Andean ranges. It has warm temperatures and high atmospheric humidity, very heavy precipitation, periodic river flooding of lowlands and all the characteristics leading to the development of a tropical rain forest.

Figure 3 shows an abridged version of the Ecological Map of Peru taken from Dr. Joseph Tossi, Jr.'s original, where all the major ecological formations are shown corresponding to the

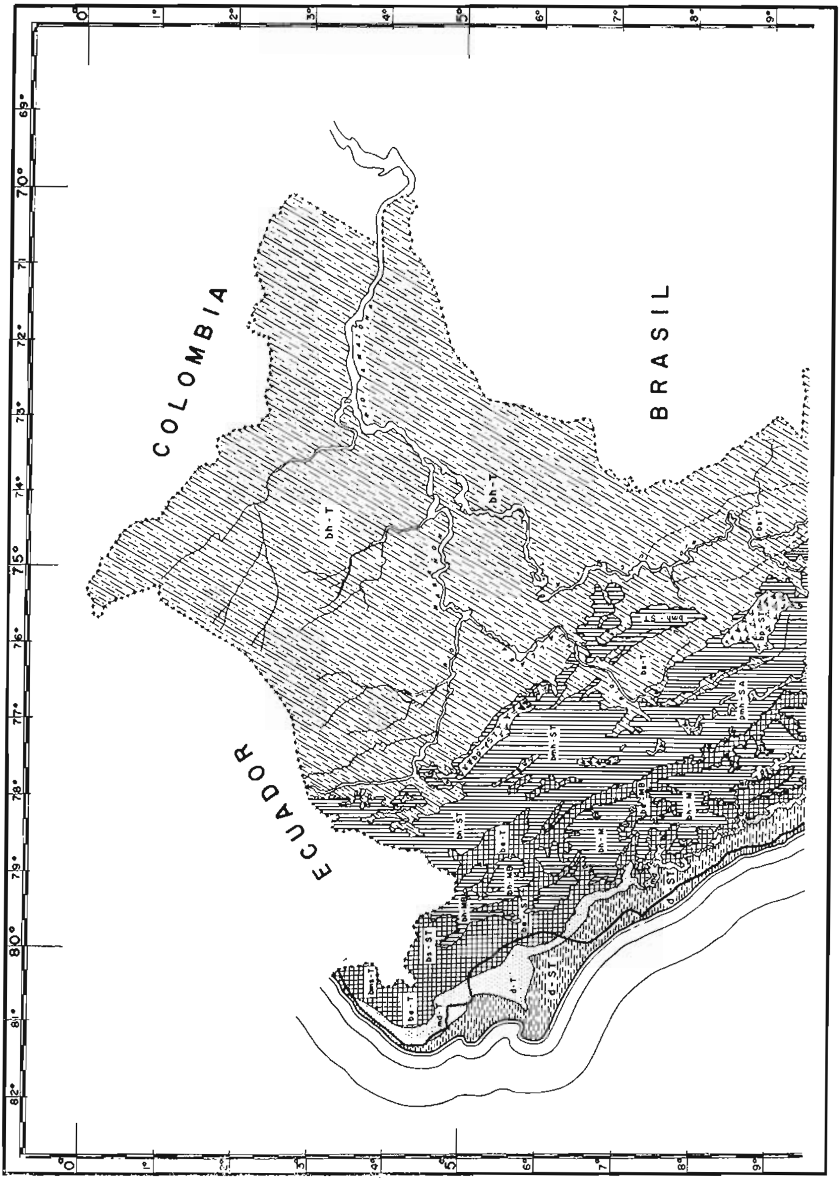
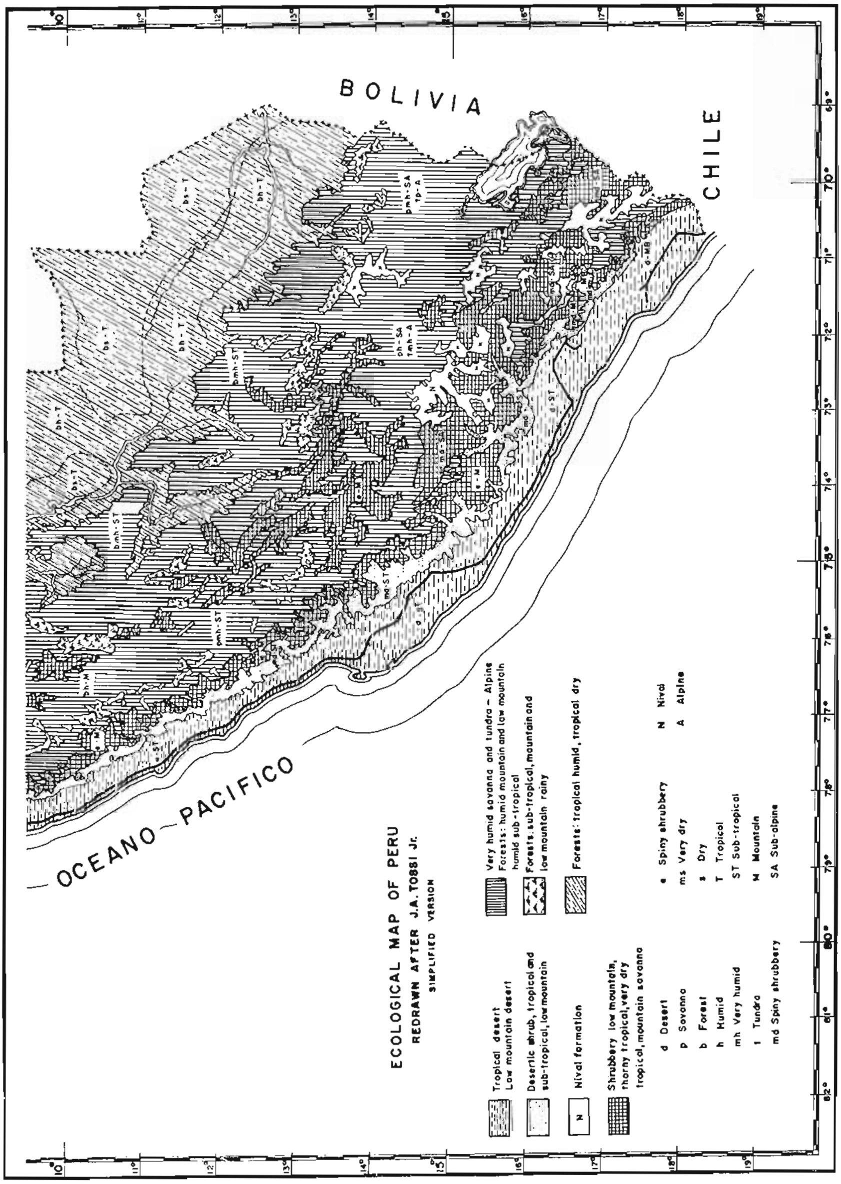


FIG. 3. Ecological map of Peru. The present abridged version was prepared especially for this publication from the original by Dr. J. A. Tossi Jr., of the Inter-



american Institute of Agricultural Sciences–Andean Zone, La Molina, Peru. (Drafted by E. Espino A.)

general groupings listed before. On this map the important corn-growing areas are largely along the coastal valleys and especially in the cross-hatched regions of the Sierra listed as shrubby low mountain, etc.

THE CULTURE AND USES OF MAIZE

A few essential facts about maize culture in ancient and modern Peru will be presented, in order to provide a background for the discussion of the evolution of maize in that country.

Peru has been and still is essentially an agricultural region. The development of superior cultures which culminated in the highly organized and extensive Inca Empire was intimately linked to the high technical progress achieved by the earlier farmers. Today 60 per cent of the 10 million inhabitants of the country are still engaged in agriculture, which is predominantly of an intensive type. They grow crops on 1,750,000 hectares of land, an average of 1,700 square meters of cultivated land per inhabitant, in irrigated coastal valleys, on mountain slopes, in inter-Andean valleys, and in jungle clearings, not only carving out a subsistence, but in addition producing enough so that agricultural products are in first order of importance of the exports of the country.

PRE-COLUMBIAN AGRICULTURE

Agriculture in Peru may have started independently in several areas; perhaps by 2,500 to 1,200 B.C. garden farming and wild plant gathering coexisted. This *Early Farming* Epoch was represented at Huaca Prieta on the Coast by cultivated plants such as cotton, squashes, gourds, beans, chile pepper, achira (*Canna* spp.), lucuma (*Lucuma obovata* H. B. K.) fruits, tubers of a reed called *papas de Junco,* and roots of cat-tails (Bennett and Bird, 1949). The existence of pounded bark cloth at early levels in Huaca Prieta is indicative of contacts with the Upper Amazon region. In the Sierra no archaeological evidence of cultivated plants of this period is available. However, we may surmise that all cold climate tuber crops, corn, and quinoa were already cultivated there, if we wish to account for their appearance in a highly evolved (domesticated) form in the coastal archaeological record of the succeeding periods.

Corn appeared on the Coast by the ninth century B.C., usually together with an elaborate form of pottery for ceremonial use and imposing temple buildings (Bushnell, 1957). Cupisnique ceramics similar to Chavin ceramics of the Ancash highlands appear with corn in Huaca Prieta, together with peanuts, warty squash, pacae (*Inga Feuillei* DC), avocado, and perhaps manioc, in the *Early Formative* Epoch. Bushnell (1957) takes the position, without specifying reasons for it, that the hypothesis cannot be held that corn arrived on the Coast from the highlands (and originally from the Amazonian forest). He indicates that recent (unspecified) clues link Huaca Prieta corn with either Tlatilco, near Mexico City, or with the Olmec culture, or with Honduras. The association of the first appearance of corn on the Coast with the first appearance of four other plant species native to the *Fluvial Yunga* of the inter-Andean valleys and of the eastern Andean slopes seems to us suggestive, contrary to Bushnell's interpretation, of an Andean or Amazonian ancestry of coastal corn, rather than a Middle American one.

Through the *Incipient Agriculture* and *Early Formative* Epochs there is no evidence of advanced agriculture. Small garden plots along the river banks on the Coast, and in level land in the Sierra, under individual family management, is likely to have been the characteristic agricultural pattern.

In the *Late Formative* and *Classic* Epochs (0-1000 A.D.) irrigation systems appeared on the Coast, evidencing the presence of organized agriculture. At this time all the arable land appears to have been cultivated in the coastal valleys (Willey, 1953). A digging stick made of algarrobo (*Prosopis juliflora* (Sw.) DC.) wood was the basic farming implement (Strong and Evans, 1952). New plants appearing on the Coast in the *Early Classic* Epoch are common beans, quinoa, canahua (*Chenopodium cañihua* Cook), and coca, while in the *Late Classic,* sweet potatoes, oca, mashua, olluco, jiquima (*Pachyrrhizus tuberosus* L.) yacon (*Polymnia sonchifolia* Poepp. et Endl.), lupines, tuna (*Opuntia ficus-indica* Mill.), granadilla (*Passiflora ligularis* Juss.), cherimoya (*Annona Cherimolia* Mill.), guanabana (*Annona muricata* L.), tumbo (*Passiflora mollissima* H. B. K. and *Passiflora quadrangularis* L.), papaya (*Carica* spp.), and pineapple, made their appearance (Bennett and Bird, 1949).

In the Mochica Period (500-1000 A.D.) on the North Coast, massive ceremonial centers, aqueducts, roads, irrigation systems and other public works were in operation. The irrigation systems covered all arable land in the valleys. The Ascope aqueduct in the Chicama valley is an excellent example of the magnitude of the irrigation structures of this period; it has an embankment 1,400 meters long and 15 meters high. Large Mochica irrigation canals are found in the Moche, Santa, and Nepeña valleys. The "La Cumbre" canal runs from the headwaters of the Moche river, 130 kilometers to the ancient city of Chanchan, later capital of the Chimu Confederacy. On the Central and South Coasts irrigation systems were in extensive use in the Supe and Maranga Periods, contemporaneous with the Mochica. In the Ica valley, on the South Coast, after the *Formative* Epoch, large irrigation canals and underground aqueducts were used.

The irrigation of marginal lands and the growing of crops with only subsurface moisture in *pozas* or artificial land depressions (Larco Hoyle, 1946) attest to the fact that crop production had attained a high degree of efficiency on the Coast, by the end of this Epoch.

In the Sierra, structures such as storage bins in the walls of Chiripa Period houses, (*Early Formative* Epoch) and terracing on many inter-Andean valley slopes provide evidence for an agricultural level of efficiency parallel to that of the Coast.

In the *Post Classic* Epoch (1000 to 1520 A.D.) agricultural skills were undoubtedly perfected everywhere in Peru and culminated in the high techniques of agricultural production during the period of expansion of the Inca Confederacy. As outstanding as their engineering feats in river canalization, terracing for increased crop acreage, and erosion control, were the social regulation of agricultural production imposed by the Quechuas, the ruling tribal group of the Inca Confederacy.

An agricultural calendar of the Incas based primarily on the growth cycle of maize (Fig. 4 to 11) has been portrayed graphically by Guaman Poma (1936) and described by other chroniclers of the Post-Conquest Period (Calancha, Betanzos, Cobo, Molina del Cuzco, Martin de Morua). Definite planting, cultivation, harvest and crop-processing operations were established in a programmed sequence, together with ceremonial festivities (Rowe, 1945; Valcarcel, 1945). The Inca, ruler of the Empire,

FIG. 4-11. *Selected reproductions of the original sketches by Guaman Poma de Ayala, depicting the agricultural calendar of the Incas in regard to the culture of maize.*

FIG. 4. August. Men tilling the soil with *chaquitacclla*s and women breaking clods.

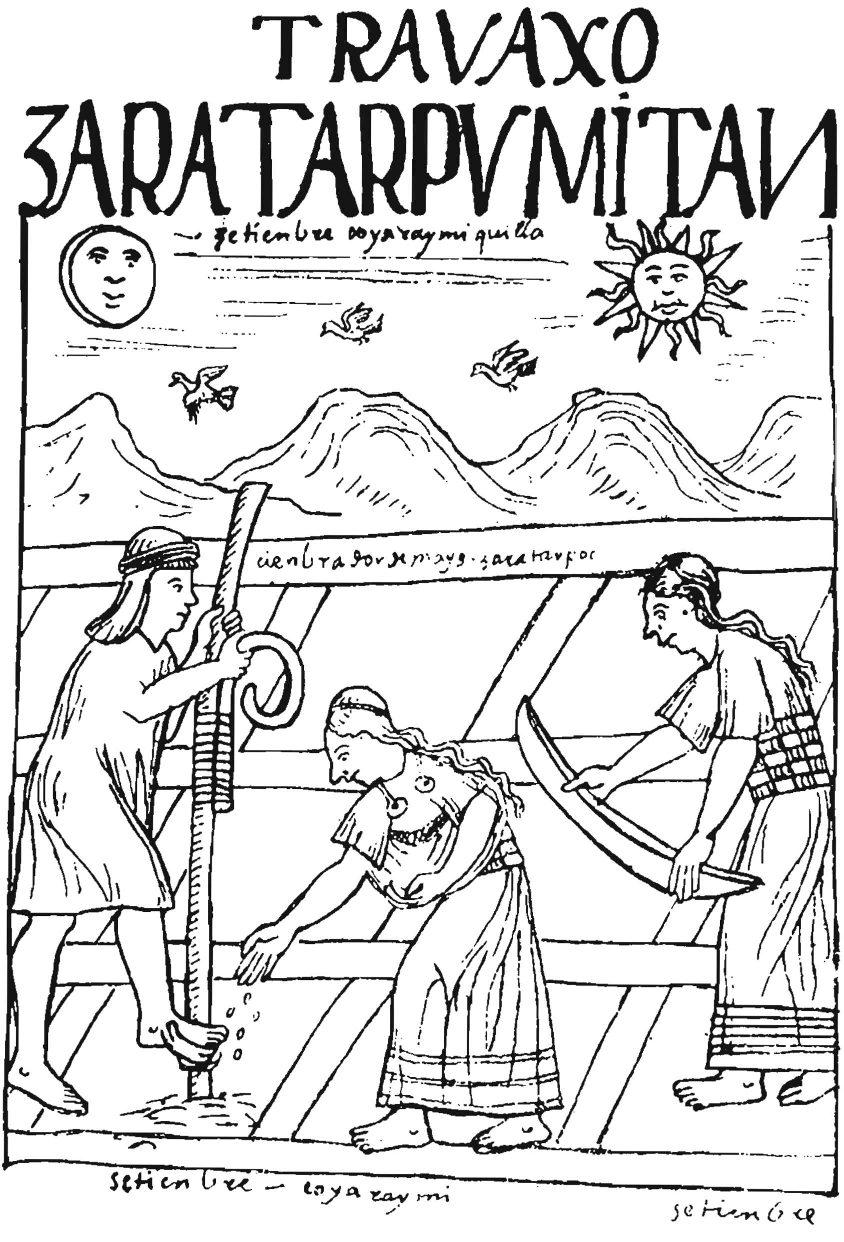


FIG. 5. September. The sowing of maize.

FIG. 6. November. Irrigation of maize.

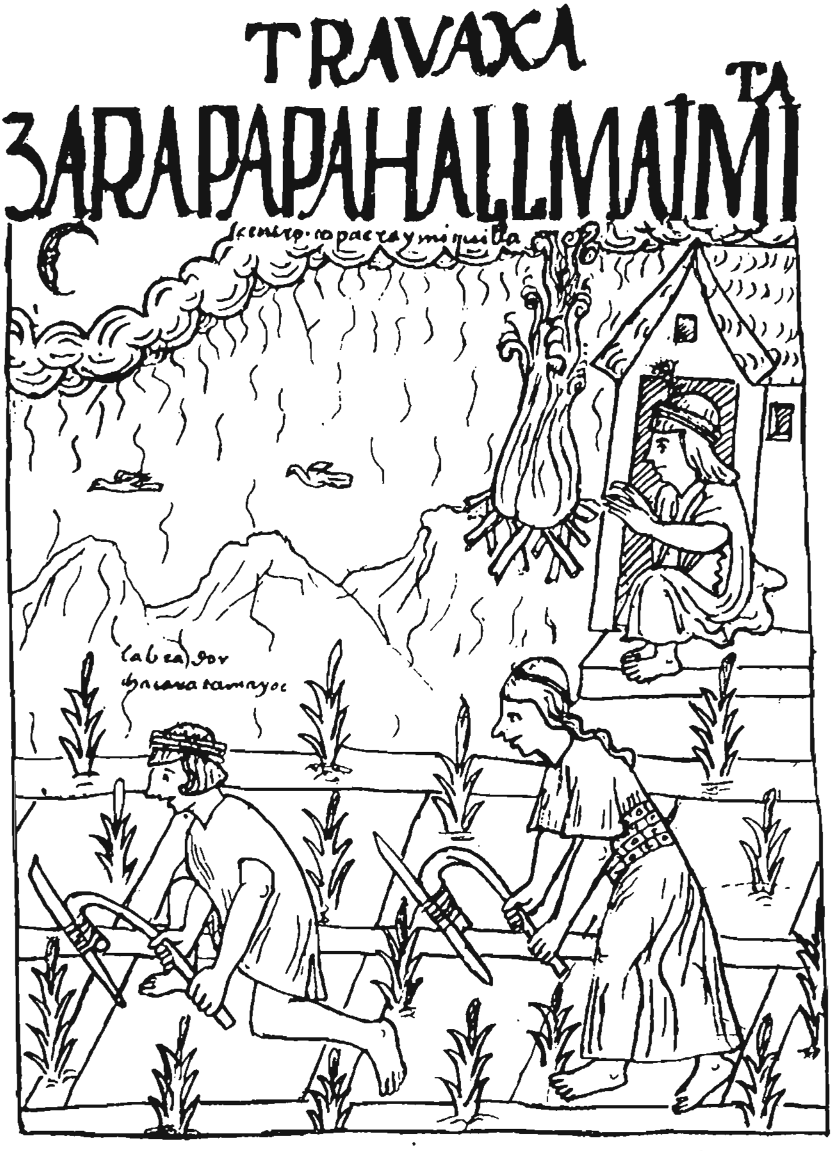


FIG. 7. January. Cultivation of maize.

FIG. 8. February. Ears filling. Rainy. Watching against animal predators.

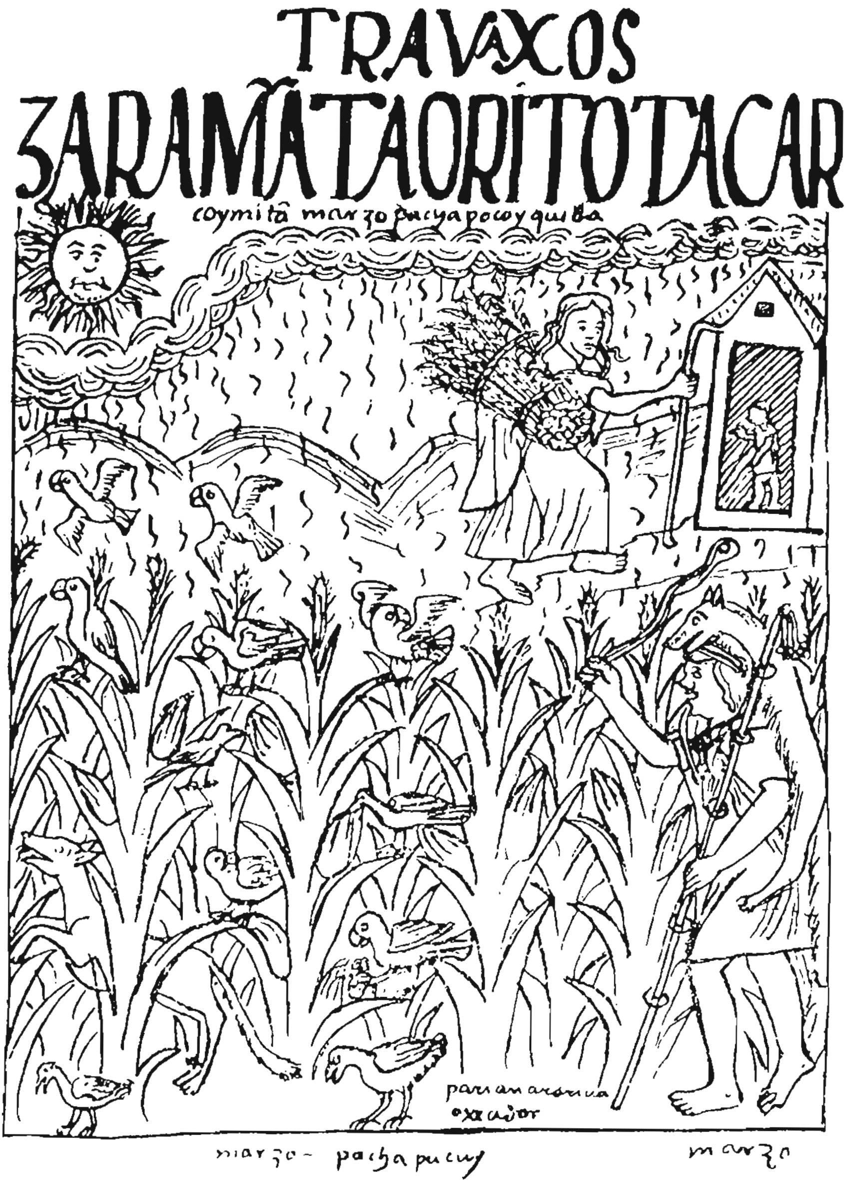


FIG. 9. March. Very rainy. Dispersing *lorito* birds in maize fields. Harvest of forage or *chala* corn.

FIG. 10. May. Harvest and preparation of stacks for drying corn on the stalk.

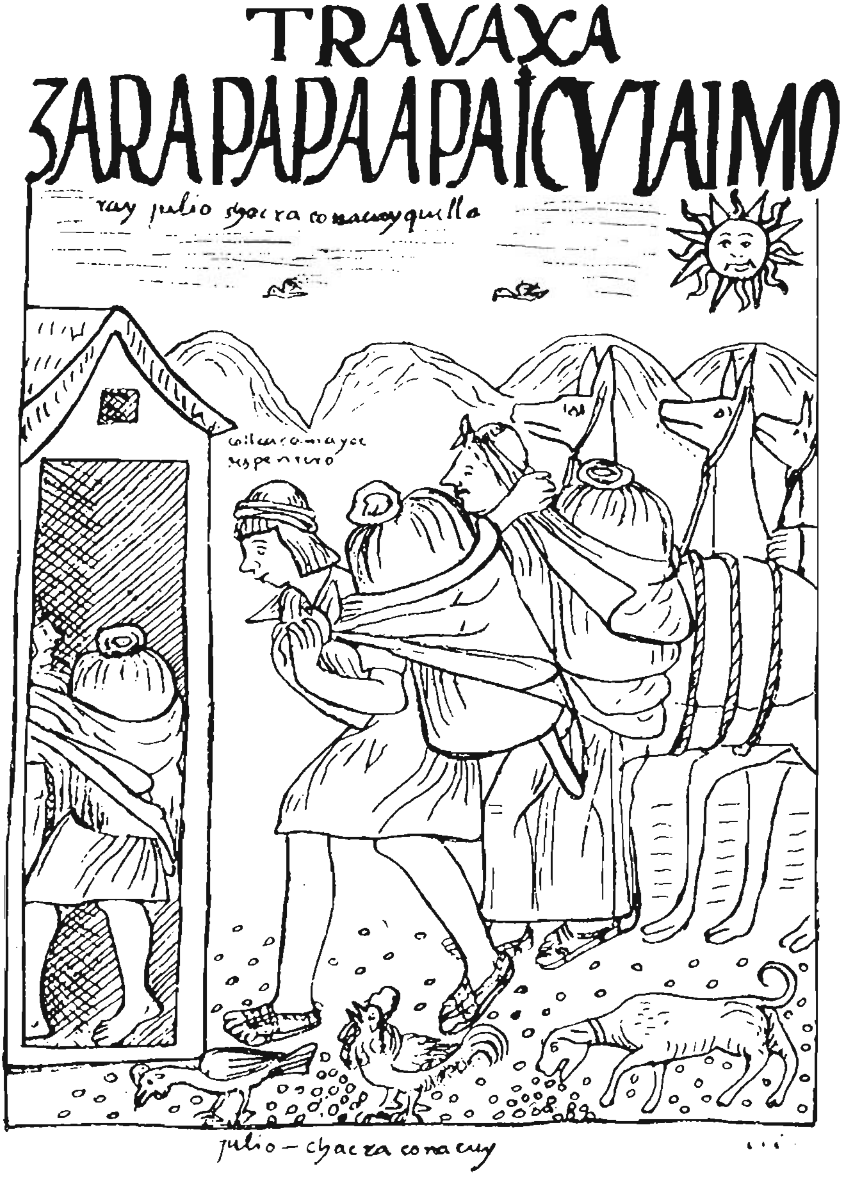


FIG. 11. July. Storage of corn grain.

accompanied by the cast of noblemen, was the first to break the ground of the Colcampata terrace near Cuzco, inaugurating the planting season (Garcilaso, 1609-1617). At harvest time the festival of *Aymuray* was observed as a thanksgiving for bountiful crops.

A definite work schedule was assigned to all agricultural workers within the Inca Empire. It is described by Romero (1937), as follows: (1st) Work on lands to support Cult (temples, priests, priestesses (*ackllas*), etc.); (2nd) Work on lands of incapacitated persons (absent in the Army, sick, old people, widows, etc.), qualified by L. Baudin (*vide* Romero, 1937) as a social assistance service within a state socialism; (3rd) Work on the lands of the members of the *ayllu* (or family community), which was the backbone of the social organization of the Quechuas; (4th) Work on lands of the *curacas* (tribal chiefs) and other functionaries; (5th) Finally, and scheduled to be last, was work on the land of the Inca. Polo (1585) considered the work done in land other than their own as a form of taxation imposed on the inhabitants of the Inca Empire.

The land of the *ayllus* or family communities was assigned individually to members of the community for life, in the amount of one *tupu* (or *topo*) per man and half a *tupu* per woman (one *topu* is equivalent to one third of a hectare).

The tillage of the soil was done with wooden sticks provided with a handle and crossbar at knee level, to facilitate pressing the stick into the soil, where leverage was applied to overturn the sod. These instruments were called *tacllas*, and were employed by men advancing through the field in a row (Fig. 4). Women followed them breaking the soil clods with *atunas* (wooden implements). All these operations were carried on with singing and rhythm (Cobo, 1653).

The irrigated lands were reserved each year for growing maize. Potatoes, ocas, and other species were grown without irrigation in other areas for one or two years and then the land was allowed to be fallow. Guano from the Coast and animal manure were used for fertilizing the crops (Garcilaso, 1609-1617).

Before the end of the 16th century, agriculture was the primary occupation of the Inca Empire, providing sufficient food for an estimated 4,500,000 inhabitants distributed over an area of 1,738,000 square kilometers (Horkheimer, 1958).

There is substantial evidence that the quality as well as the quantity of the diet of the inhabitants of the Inca Empire was adequate most of the time (Horkheimer, 1958). Some 70 species of plants had been domesticated and were being utilized by the Peruvian Indians by that time (Cook, 1925). Many of these species are today widely scattered, contributing to feeding the populations of the world.

The disruption of the Inca Empire had as its sequel a collapse in organized agriculture and a change in its pattern, from state planning and control of its major features to an individualistic subsistence type. The removal of large masses of Indian population for labor in mining, and the lack of interest of the early Conquerors in farming, contributed to a deterioration of the irrigation and terracing systems in many areas of Peru and a retrogression of agricultural production in general. This situation continued through the Colonial and a great part of the Republican Periods, establishing a clear cut contrast with the state of agricultural development in pre-Columbian times.

MODERN AGRICULTURE

The rough topography and the extreme climatic conditions prevailing in the different regions of Peru have limited the agricultural areas of the country to a mere 1.3 per cent of its total territory. Further horizontal expansion is prevented by these same topographic and climatic factors, which undoubtedly prevailed also in ancient times. It should, therefore, come as no surprise that a great deal of the cultivated land of Peru is rather intensively worked, since it supports one of the densest populations (per cultivated unit area) in the world. Irrigation, weed control, terracing, and the use of fertilizers have long been standard practices in Peru. This country is among the first three on the American continents in irrigated acreage and the second in total and per unit area fertilizer consumption.

The most important agricultural regions of Peru are the Coast and the *Quechua* region of the Sierra, followed by certain areas of the *Suni* and the jungle.

The agriculture of the Coast is carried on in its irrigated valleys, which are triangle-shaped, gently sloping to the ocean and made up of alluvial deposits on the river ejection cones. Landholdings are of medium to large size. Modern agricultural methods are in use on many farms. Crops with the largest acreage on the Coast are cotton, corn, sugar cane, rice, alfalfa, and common beans.

A pattern of agriculture in sharp contrast to that of the Coast is found in the Sierra, where the majority of the Indian population of the country lives. This is largely a small-scale, subsistence type of agriculture, carried on, as a rule, on small plots of land, with inefficient farming methods. The particular crops grown by the Indians are suited to their dietary preferences, and are seldom selected on the basis of commercial value. Large- and medium-scale farm operators, seldom Indians, are the minority exception to this generalization, and grow crops of improved varieties of highest commercial demand.

In the Sierra, the inter-Andean valleys at altitudes below 2,400 meters produce corn, wheat, sugar cane, and coca (*Erythroxylon Coca* Lam). In the *Quechua* region of the Sierra, corn, wheat, potatoes, and broad beans (*Vicia Faba* L.) are the most important crops. On the *Suni* and *Jalca* heights, potatoes, barley, oca (*Oxalis tuberosa Molina*), olluco (*Ullucus tuberosus* Calda), mashua (*Tropaeolum tuberosum*, Ruiz and Pavon) and quinoa (*Chenopodium Quinoa* Wild.) attain their greatest economic importance. The *Puna*, with its natural pastures and low temperatures, is a sheep-, llama-, and alpaca-raising region.

The altitudinal limits for growing grain and tuber crops are higher in the south and central Sierra, where they reach 4,100 meters, than in the northern Sierra, where agriculture ceases above 3,500 meters. Weberbauer (1945) suggested that the greater rainfall of the northern Sierra could be the factor limiting growth of crops at such high elevations. Sauer (1950), however, assumed that longer summer days allow corn growing at higher elevations in southern Peru, Bolivia, and Chile than in more equatorial areas, such as Quito.

The eastern Andean slopes at intermediate to low altitudes are important coffee-, tea-, citrus-, banana-, coca-, and cacao-producing areas. This region has a low density of population and its agricultural production is concentrated in specific, recently colonized areas.

The Amazon Basin lowlands are largely agriculturally underdeveloped. Rubber and tropical woods are their main economic plant products.

MODERN MAIZE CULTURE

A visualization of the distribution of maize culture in Peru at the present time may be gained by referring to Tables 3 and 4.

The valleys of the northern and central Departments of La Libertad, Ancash and Lima produce most of the maize of the

TABLE 3. Crops with Largest Area Under Cultivation in Peru in 1958.

Crop	*Area (Hectares)*
Maize	238,289
Cotton	237,627
Potatoes	217,665
Wheat	135,149
Rice	70,636
Sugar Cane	61,751

TABLE 4. Area Planted to Maize and Total Production per Department in Peru, in 1959.

Department	*Area (Hectares)*	*Total Production (Metric tons)*
Amazonas	14,800	14,800
Ancash	26,160	50,664
Apurimac	7,595	5,461
Arequipa	7,700	14,941
Ayacucho	42,000	28,000
Cajamarca	20,000	20,000
Cuzco	23,149	27,846
Huancavelica	6,816	8,014
Huanuco	9,901	9,799
Ica	4,733	6,949
Junin	9,953	8,095
La Libertad	17,000	24,000
Lambayeque	14,493	13,669
Lima and Callao	15,500	25,000
Loreto	100	150
Madre de Dios	300	414
Moquegua	1,400	2,000
Pasco	2,410	2,410
Piura	7,600	10,000
Puno	6,415	7,458
San Martin	6,500	9,000
Tanca	3,127	6,819
Tumbes	1,455	2,838
Total	250,098	298,327

Coast. The North Coast valleys, north of Casma—with the exception of the Santa valley—have a water supply insufficient for effective irrigation; all have higher average temperatures and lighter cloud covers than the Central Coast valleys. North Coast maize is consequently earlier and more drought and heat tolerant than Central Coast maize.

Until recent years, most of the North Coast maize was made up of the floury races, Alazan, Mochero, Pagaladroga, and Jora; a flint to semi-dent race, Rienda; and one dent introduction of the Mexican Tuxpeño racial complex, Arizona.

Most of the corn grown on the North Coast is used as raw material for the manufacture of *chicha* (corn beer) in scores of local family-run establishments.

In these northern coastal valleys, corn is planted in January or February when the rivers receive their first waters, originating as precipitation on the Sierra. Enough water is usually available for a pre-tillage and a single additional post-planting irrigation. Corn is planted in small fields, crisscrossed with earth ridges (Fig. 14) to permit flooding, as in rice fields. Heavy flooding and deep silty loam soils allow for enough water retention to enable the maize crop to grow to maturity, with no additional irrigation.

On the Central Coast, maize is grown mostly for its grain, for animal feeding or industrial use; or as a silage and a green-fodder crop for dairy herds. To a smaller extent it is grown for direct human consumption as green corn. Ample irrigation water and lower average temperatures allow a longer season, and, therefore, higher yields than on the North Coast. Corn growing is largely mechanized in this area and improved varieties and hybrids are in much wider use than in any other parts of Peru.

All along the Coast, two crops of corn per year for grain production, and up to four for forage production are possible, depending on water supply and efficient insect control. Yields of 2.5 of dry grain per hectare on the North Coast and four tons per hectare on the Central Coast are normally obtained by good farmers.

Important corn-growing areas of the Sierra are to be found in Ancash, Cajamarca; the Mantaro, Apurimac, and Urubamba valleys; and all the middle altitude areas of the Andean Cordilleras. (Figs. 12-13). The greatest concentration is in the Department of Cuzco, particularly in the Urubamba (Vilcanota) valley,

FIG. 12. Pre-Columbian terraces for growing corn, at Pisac, Urubamba valley, Cuzco. (Photo, courtesy Mr. Abraham Guillen)

FIG. 13. Typical middle elevation corn fields of inter-Andean valley bottoms, at Mantaro Quebrada, Huancavelica.

Fig. 14. Corn grown under irrigation at Lambayeque, North Coast.

Fig. 15. A corn field in a jungle clearing in the middle Huallaga valley. Corn is usually the first crop following the clearing of virgin tropical forests.

famous for its large-kernelled Cuzco corn. Corn in this valley is practically a monoculture, repeated year after year, to the almost absolute exclusion of any other crop. High densities of planting, rich soils, high levels of fertilizer application, irrigation, a perfect climate for growing corn, and highly selected varieties of the races Cuzco Amarillo and Cuzco Gigante, are responsible for very high yields which sometimes surpass nine tons of dry grain per hectare. In most Sierra locations, however, corn-yields seldom exceed one-and-a-half tons of grain per hectare.

In the majority of corn-growing areas of the Sierra, this cereal is hand planted in the small fields of Indian farmers, following preparation of the land with a primitive wooden plow equipped

FIG. 16. Harvest of Cuzco Gigante corn in the Quispicanchis valley, Cuzco. The ears are husked from the dried stalks, and spread for further air-drying.

with a soil-scratching iron tip and pulled by oxen. On steep slopes or in small plots a wooden digging stick called *chaquitacclla* is used to till the soil. This instrument has not been modified much since Inca times, as evidenced by the resemblance of the present-day instrument to that depicted in Fig. 4, reproduced from a sketch dated shortly after the Conquest. On valley-bottom and flat lands, mechanization in tilling operations is becoming more common.

Corn is usually planted alone, but is also grown associated with quinoa and broad beans. Planting time varies from late August in irrigated areas in southern Peru, to mid-November in the lower altitudes of the northern Sierra, and the harvest comes from May to June. Rotation is practiced with potatoes, small grains, and broad beans in some higher elevation areas. In such cases most of the fertilizer in the rotation is applied to the potato crop; corn is occasionally and sparsely fertilized with *Guano de Islas* (an organic fertilizer which comes from the islands off the Peruvian littoral) and sheep manure. At harvest time the stalks are usually cut a few inches above ground, and are left lying to speed up the drying of the ears. At the proper time they are collected, carried in bundles on the farmers' backs and piled near their homes, where the ears are usually husked by women (Fig. 16). The ears are then left to dry on grass mats under post-harvest seasonal conditions of low atmospheric relative humidity and minimum likelihood of rainfall. Storage space for the dry ears is later found by the farmer in a room in his house (Fig. 17).

In the jungle (*Selva*), small-scale plantings of corn (Fig. 15) are made on newly cleared hillside lands and on river beaches. Little care other than weeding is given to the growing crop. Corn may be grown either alone or associated with common beans, cassava, or banana, and sometimes as a filler crop in the initial years of permanent cultures of coffee or cacao.

USES OF MAIZE

Maize is used in Peru primarily for human food, and secondarily as animal feed and fodder. As human food it is and has been consumed since ancient times in a great variety of forms, the most common of which are the following; (1) *Kcancha,* is a toasted or parched floury or sweet corn, used before meals, as a bread substitute, or carried by the Sierra Indians for snacks

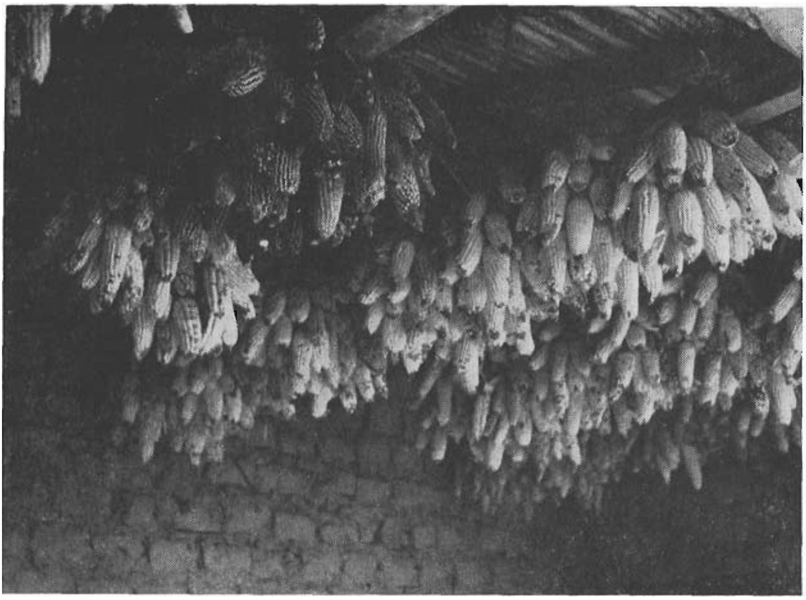


FIG. 17. Storage of ears of Ancashino corn seed in the Callejon de Huaylas region, Ancash. Ears with yellow and with red-white capped kernels are kept separate for independent planting.

during their work; (2) *Mote,* made by boiling dry floury grain, is the usual food at lunch and supper throughout the Sierra; (3) *Chicha,* or corn beer, is made by fermenting an aqueous extract of pre-germinated corn grain; its consumption is particularly high on the North and South Coasts, where it is called *claro* and *jora,* respectively; red or cherry pericarp corn is preferred for use in preparing *chicha;* (4) *Choclo,* which is boiled green corn, is particularly preferred on the Central Coast; only floury varieties are used for *choclos;* (5) *Confite,* is popped corn, also called *kcancha* in many areas; (6) *Taml, sanku, patashka, huminta, chuchoca, lawa, mashika, mazamorra, pepian,* etc. are some of the many simple and more widely used native food preparations based on floury corns. Mejia Xesspe (1931) gives a good account of the more important additional uses of corn as food in the highlands of Peru.

It is interesting to note that corn bread is very seldom prepared by the Peruvian Indians, in contrast to the widespread use of corn for this purpose by Colombian, Mexican, and Guatemalan high-elevation Indian groups.

Parts of the corn plant other than the grain are also used for human consumption. The stalks or *huiros* of Sierra corn are chewed at harvest time for their high sugar content; corn silks are boiled to make *emoliente,* a soft drink which is claimed to have diuretic properties; the cobs of deep purple races of maize are used to dye foods; and even corn pollen seems to have been used as food in Inca times.

In large cities corn is used also in industrial food preparation, and to a limited extent complements wheat flour in making bread.

Corn is utilized as a feed grain in most low-elevation areas in Peru, particularly on the Coast. Flint and semi-dent corn races are preferred for this purpose, although only 40 years ago a great deal of the hog raising on the Central Coast was based on the use of floury corn races. Very little corn is used for feeding animals in the Sierra.

Corn planted thick for fodder is called *chala;* the Central Coast, particularly around Lima and other large cities, is the most important green fodder and silage-producing area, for feeding to dairy herds raised in closed pens, with almost no pasturing. Dry corn stalks, after the ears have been husked, are used for animal fodder throughout the Coast and Sierra. Dried corn cobs are used as fuel in many rural areas.

THE EVOLUTION OF MAIZE IN THE CENTRAL ANDEAN REGION

The amazing genetic variability exhibited by maize in the central Andean region today, as compared to the rather limited variability of this species in the same region 3,000 years ago, and the enormous increase in ear and kernel dimensions which has occurred during this period, are facts that denote a greatly accelerated evolutionary process in maize, almost unparalleled in speed and in the magnitude of change, among cultivated plants.

More detailed knowledge of the steps in the evolution of maize in Peru will have to wait the completion of the studies on archaeological material, which are being conducted at the present time. We are now, nevertheless, in possession of enough information to permit a satisfactory interpretation of this process, based on the available facts to which some limited hypothetical interpolations have been added.

It is evident that the evolutionary process undergone by maize in Peru has resulted in an increase in the range of phenotypic and genotypic variation; an overall increase in the range of adaptation of the species, with a higher specificity of adaptation of particular races to particular habitats; and a considerable increase in yield potential in response to improved agricultural techniques.

These large evolutionary changes have been brought about by the following factors: (a) the characteristic monoecious habit of the maize plant and the fact that its seed formation is the result of almost complete cross-fertilization; (b) various cytological and genetic characteristics, such as great length of the chromosomes; relatively high mutation rates for many genes; high frequency of non-homologous chromosome pairing; high-frequency of genetic recombination, unimpaired by any of the crossing over-reducing mechanisms found in other plant and animal species; (c) its entire dependence on human propagation and hence on human preferences; (e) the origin of multiple genetically distinct populations isolated by geographical barriers over a large land area, and the subsequent confluence of such populations; (f) large heterotic responses in crosses of populations with a previous history of isolation; (g) genetic ability to produce a large number of seeds per plant, a character sought by artificial selection in the development of some races and very likely associated with other components of evolutionary fitness; (h) the manner of its cultivation, (hill planting and row spacing), and of harvest which makes easy the identification and selection of single plants; (i) introgression of teosinte and Tripsacum species.

All these factors have had a bearing on the evolution of maize in Peru since the beginning of its cultivation. The last factor has played an important but restricted role, as compared to the preeminence of teosinte-hybridization effects on the evolution of maize in Mexico and Central America (Wellhausen *et al,* 1952, 1957).

The evolutionary history of corn in Peru may be thought of as comprising the following stages, presented here in approximate chronological sequence:

a) Domestication in the low to middle altitudes of the Andes.

b) Formation of primitive races and extension of the original range of adaptation of the species.
c) Tripsacum introgression.
d) Limited introduction of maize, which was domesticated in areas outside the central Andean region.
e) Interracial hybridization, and formation of early hybrid races.
f) Expansion of the area of cultivation, improvement of agricultural methods, interracial hybridization, and formation of secondary hybrid races.
g) Modern introduction and the formation of incipient modern races.

ROLE OF THE INDIAN IN THE EVOLUTION OF MAIZE

Much has already been written about the role of the Indian farmer in the improvement of maize (cf. Weatherwax, 1954, Chap. 17, for example), so little need be said here, other than to reemphasize his success as a breeder, and to note the particular sociological factors which have caused an intensification of the results of his breeding work in the Peruvian region.

The Indian of the Andes and of the coastal valleys in Peru seems to have attained an early integration of maize with his other basic motivation factors. In no other way can we explain his intimate relationhips with maize, as expressed in so many ways in his artistic, religious, and social activities.

It seems obvious that the Peruvian Indian had much more than a casual farmer-plant relationship. He must have had a deep but simple empirical knowledge of maize, as regards its physiology, its morphological variation, and its breeding behavior.

Weatherwax (1942) and Kempton (1937) projected an image of the Indian farmer as a skilled breeder, who directed the evolution of his cultivated plants towards definite desired phenotypes. Wellhausen *et al* (1957) discussed the role of the Indian farmer as a breeder of maize with reference, mainly, to the Central American region. Without minimizing the importance of his role in the evolution of maize, they questioned that he ever acted as a plant breeder in the modern sense of visualizing a new phenotype and working towards its attainment. According to their view, the Indian farmer was primarily instrumental in directing the evolution of maize into various pathways through selection, rather than in starting or promoting it through the powerful instrument of hybridization.

We could reconcile these two opposing points of view in the context of the evolution of the pre-Columbian societies in Peru. In the early stages of these societies, the Indian farmer, having a more limited agricultural tradition of skills, and a looser social responsibility to his community, although consciously striving to improve maize yield by selection, did it in a not-too-rigorous manner, preserving as he went along the abundant variation he encountered. His procedure was simply mass selection of the larger ears, as well as of those with fancy shapes and colors. As the Andean societies consolidated and evolved into the highly technical Inca Confederacy, an increased necessity resulted for the feeding of larger populations, and for maintaining sizable food reserves. The latter were necessary in view of the division of labor, with its concomitant allocation of substantial segments of the population to the public works programs and to expanding armies, and for the provision of security against eventual crop failure.

In the highly organized Inca Empire, the control of agricultural production, in which maize was preeminent, fell to a large degree under state supervision. The races regarded as most desirable were undoubtedly grown in state and priests' land to provide the strategic food reserves of the state. It seems plausible that since such advanced agricultural techniques as irrigation, terracing, row planting and fertilization were being employed in growing maize when the Spaniards arrived in Peru (Garcilaso de la Vega, 1609), then seed selection and state-organized varietal allocation to specific corn-growing areas are likely to have been practiced also. We do know that a specific type of yellow corn, Morocho, was grown especially for feeding the army (Yacovleff and Herrera (4) p. 61, 1934).

At this stage, we may be able to visualize the Indian farmer as a highly integrated element of a complex society, owner of an impressive agricultural tradition and of multiple skills, devoting a large part of his energies to the working of community land. It was at this time that he exercised his best breeding ability, which was manifested in an orientation of the evolution of maize, through selection, towards larger yield per unit area (their *tupu*) and towards the stabilization of racial types and their preferential use.

State action was not only responsible for the early typification of the Cuzco races in the highly selected form in which they are known today in the Cuzco region, but it also accounts for the diffusion of certain high-yielding Peruvian Sierra races to all the areas conquered by the Incas, including the Peruvian Coast and parts of the present countries to the north and south of Peru. It does not seem, however, to have been extensive enough or of sufficient duration to have consolidated the variability of maize into a few types, since this is certainly not the situation found today.

The Indian in Peru may never have reached the knowledge of purposeful hybridization as a breeding system, but he must have experienced the favorable effects of planting mixtures of different seeds of one or few races on the yields of succeeding generations. Similarly, he did not reach the stage of individual plant selection, but he must certainly have recognized the best yielding races, and propagated them in preference to others, at least during the Inca Epoch.

The greater agricultural skill of the Central Andean Indian and concerted state action in late prehistoric times seem to have imprinted a pattern of human selection of maize in Peru, different in its operation and end results from those of other primary corn areas.

GEOGRAPHICAL ORIGIN

Proof of the existence of maize, presumably about 80,000 years ago, in the Valley of Mexico, was presented by Barghoorn, Wolfe, and Clisby (1954). The existence of maize long precedes, therefore, any evidence of agriculture and, very probably, of any human habitation in America. Thus the question of the geographical origin of maize appears to be well beyond the reach of any information that might be obtained from archaeological sources. Having available no more than the fossil pollen evidence of Barghoorn *et al* (1954), any discussion of *the* place of origin of maize in America is of necessity limited by the lack of further data.

As Kuleshov (1929) and others have pointed out, there is a difference between "the place of botanical origin" and "the place of domestication." The place of geographical or botanical origin of maize has been located in the Mexican or Middle American region by Weatherwax (1936, 1954), Randolph (1959), Vavilov (1931), Kempton and Popenoe (1937) and Harshberger (1893), mainly on the basis of the generalized assumption that the center of origin of a species must be in the area where the greatest variability of its wild relatives exists today. Although never analyzed in detail, it has been stated by the proponents of this hypothesis that maize domestication took place at a later date in the same center of origin.

The assumption that domestication follows the origin of maize in a given center is not supported by any concrete evidence. On the other hand, even if we accept a Middle American origin of maize, there is rather strong evidence for the geographical independence of the places of origin and of subsequent domestication. Such evidence comes from: (a) the break in continuity of the presence of maize pollen in the drill cores studied by Barghoorn *et al* (1954), from a level 69 meters deep to an upper level of 3.6 meters, indicating a very long discontinuity in the presence of corn at this site (Mangelsdorf and Reeves, 1959); (b) Mangelsdorf and Reeves' (1939) hypothesis of the origin of teosinte. This does not require a common place of origin for corn and teosinte, and although not proven, it has a strong factual basis, and does away with Vavilov's requirements of geographic proximity between the place of origin of a cultivated plant and the area occupied by its nearest wild relative; (c) the occurrence of the greatest known variability in maize in Peru (Kuleshov, 1929), far distant from the area where its relatives thrive; (d) the present occurrence of the most primitive living maize races in the Peruvian Andes.

The reasons presented above tend to support the hypothesis of the independence of the place of origin from the place of domestication. However, these reasons do not disprove the possibility that the domestication of maize occurred in Middle America. On the contrary, circumstantial evidence may be adduced to support this last possibility. Such evidence is as follows:

(a) The oldest dated archaeological specimens of maize, 5,600 years old, originated in Bat Cave, New Mexico (Mangelsdorf and Smith, 1949) and precede the earliest dated archaeological maize specimens from Peru, which come from the Huaca Prieta site in the northern coastal valley of Chicama, estimated to be only 2,900 years old (Bird, 1948). Other Middle American archaeological maize specimens believed to be 4,445 years old preceding Huaca Prieta come from La Perra Cave (Mangelsdorf, MacNeish and Galinat, 1956) and from a site in the Sierra de Tamaulipas, northeastern Mexico, dated at approximately 3,945 years (MacNeish, 1955, 1958).

(b) The migratory trends of the early Asiatic colonists of America were from north to south. Earlier settlement in Middle America than in South America was conducive to the formation of what Spinden (1917) has referred to as an "archaic substratum" of American culture in Middle America. It has been tacitly assumed by students of anthropology and plant origins that one of the elements of the cultural substratum acquired by primitive man in Middle America was the domestication of plants. From this area, the knowledge of both plant domestication, and of maize and other plants supposed to have been domesticated in this center, diffused southward (Willey, 1955).

A suggestion establishing the Chibcha areas in Colombia as the center of maize domestication was advanced by De Candolle (1886). He justified his proposal on the basis of the contention that human migrations are normally multidirectional; therefore, a center intermediate between the two main areas of maize variability (Middle America and the Central Andes) would have been the domestication nucleus from whence the diffusion of maize occurred. More recent proposals favoring a Colombian center of domestication were presented by Birket-Smith (1943) and later were reviewed by Mesa Bernal (1955). These do not have a strong factual basis and have been adequately interpreted by Roberts *et al* (1957), who consider the Colombian area as a crossroads in the diffusion pathways of maize.

DOMESTICATION OF MAIZE

An independent domestication center of maize in Peru, in addition to the Middle American center, is postulated here. Such a proposal was made first by Mangelsdorf and Reeves (1959). Without repeating their convincing arguments, we intend to add here additional evidence, and establish the hypothesis of maize domestication in Peru on a wider background of facts.

We shall endeavor to prove that the circumstantial evidence in favor of a Middle American origin of domesticated maize neither limits nor excludes the possibility of a domestication center in Peru; and that there is positive evidence in favor of our hypothesis.

a) *Archaeological evidence.* The archaeological corn of Mexico, although found in a dry area, was grown under conditions favoring rainfall, while the archaeological corn of the Peruvian Coast was grown under irrigation. To anyone familiar with the extreme desert conditions of the Coast, it will seem inconceivable that irrigation agriculture arose *de novo.* It was, in all probability, preceded by a long process of agricultural development in the highlands, first as precipitation farming and later under irrigation. This would point to the Peruvian highlands, and not to the Coast, as the region where archaeological material of an age comparable to that of the Mexican finds ought to be located. Unfortunately, since they were not expected to be as rewarding in manufactured objects, the primitive archaeological sites in the highlands of Peru have not been explored to anywhere near the extent that the coastal sites have been. The difference in age of the earliest Middle American and the earliest Peruvian archaeological maize reflects the chronological difference between two stages of agricultural development, which took place independently in each of the two centers, and therefore cannot be used as evidence for the unique domestication of maize in Middle America.

b) *Diffusion of domesticated maize.* The contention that agriculture must have originated in Middle America, because of priority of settlement, leads to the implication that, if wild corn was growing there, it was domesticated and then carried south in successive migratory waves, which accounts for its presence in other areas.

Recent archaeological evidence indicates that human migrations had populated all areas of the American continent long before agriculture had originated in any of them. That man had traversed the entire span of the American Continent from the Bering Strait to the Magellan Peninsula by 5000 B.C. is now definitely established (Bird, 1938). The antiquity of man in the Peruvian Andes is claimed for at least 9,000 years (radiocarbon dating at 9,525 ± 250 years, as evidenced by mesolithic human remains at Lauricocha Cave, in central Peru) (Cardich, 1958, 1960). Coastal fishermen lived in Peru, at least around 5000 B.C. (Engel, 1960). An early site with human habitation estimated at 7000 to 8000 B.C. has recently been found in the Ecuadorian Andes, near Quito (Mayer-Oakes and Bell, 1960). Consequently, it is apparent that man had been in the Andean region long enough to undergo a social evolution separate from that of the Middle American region, and thus could have produced an independent invention of agriculture.

The possibility of contacts between the Central Andean and the Middle American regions in the Neolithic Period is not denied, in fact, these contacts probably were quite continuous. However, it is suggested that the Andean man, confined to relatively small areas in inter-mountain valleys surrounded by massive mountains, which in most instances limited or even prevented free roaming, eventually was driven to a sedentary way of life, and relied gradually more and more on plants as a source of food, and less on hunting. He fell fortituously or by repeated trial and error into knowledge of which of his habits or actions enhanced the production of the plant products that he consumed.

A multiple origin of agriculture, for which the term *polyagrogenesis* is here suggested, has probably been the rule within the Central Andean region. It is not conceivable that the domestication of 70 species of plants (Cook, 1925) in this region came about by diffusion of the knowledge of agriculture from a single center, after a single culture had developed the idea of domestication.

It is conceivable, on the other hand, that agriculture in Peru had three developmental regions which were either simultaneous or time-lagging—the Coast, the highlands, and the tropical and subtropical eastern lowlands of the Andes and Amazon Basin. In the coastal area early farmers domesticated cotton, squash (*Cucurbita Moschata L.*), and gourd (*Lagenaria siceraria* (Mol.) Standl.), or these crops were introduced by early settlers from Central America, where they appear to have originated (Whitaker and Bird, 1949). In the inter-mountain highland valleys, lima beans, and maize were being domesticated, while in the eastern lowlands manioc, peanuts, and sweet potatoes became cultivated plants. If Sauer's (1952) hypothesis that seed agriculture in South America was preceded by a root-crop agriculture is accepted, both the Sierra and jungle would have preceded the Coast in agricultural development.

Positive support for this hypothesis of domestication of maize in Peru or elsewhere in South America comes from the following facts:

a) The earliest appearance of maize on the Peruvian Coast at the sites of Huaca Prieta (Towle, 1961), Supe (Towle, 1954) and Cruz de Hueso (Engel, 1955) is simultaneous with the appearance of peanuts and possibly manioc. Peanut shells have also been found associated with corn in shell mounds in a presumably early site at Bahia de la Independencia, Ica, in preliminary explorations in which the author, Dr. Dwight Wallace, and other archaeologists participated. A corn husk with deep anthocyanin pigmentation similar to those of Sierra races was found at this site. This husk was very likely of Sierra corn or of a coastal-grown type that had not been in cultivation there too long.

In what appears to be a pre-ceramic site near Huarmey (on the north-central Coast), corn material has been found by David Kelly, without any peanut association. This would be the only exception to the correlation of early appearance of corn and peanuts known to the authors. The race involved is a popcorn type which exhibits ear fasciation and globular shape (Mangelsdorf, personal communication), characteristics which are common to the primitive popcorn races of the Andes.

If the statistical-contingency association of early appearance continues to hold in future excavations of early coastal sites, it could only mean that the introduction of corn and peanuts to the Coast was simultaneous and proceeded from a single geographical region. The simultaneity of presence of corn and peanuts is taken in a statistical sense to indicate high but not absolute association resulting from a main trend of movement, but would not preclude, of course, the appearance of either crop independently in a limited number of sites, and the possibility of corn coming from more than one direction.

Since the centers of origin of peanuts are generally recognized to be in a wide area of central South America from northern Argentina (Krapovickas and Rigoni, 1957) to the eastern Andean slopes of Bolivia and Peru, and the region south of the Amazon River (Gregory, personal communication), and to the Brasil-Paraguay border area (Chevalier, 1929), it would appear evident that the corn-peanut movement to the coast originated in the Andean region and incipiently in the Amazon Basin. The archaeological peanuts of the Coast of Peru have already been shown to be similar to those of the eastern Andean lowlands (Ames, 1939).

It is interesting to note that in several excavated sites on the Coast, the peanut is second only to corn in abundance. This is perhaps not surprising in view of the efficient dietetic and agronomic complementation of the two species. It suggests furthermore the possibility that they were introduced from the east to the Peruvian Coast, as an organized and balanced agricultural system, superimposed on the primitive system of growing gourds, beans, and squashes, complemented by hunting and fishing.

At this point it would be well to recall that all the available information indicates a late introduction of peanuts from South America into the Mexican area. The Aztec word for peanut, *Tlalcahuatl,* meaning "ground cacao" is evidently a new, derived name for a new plant, previously unknown (Sauer, 1950).

The argument elaborated above would enable us to limit the hypothesis held by some anthropologists (i.e. Willey 1955, 1960), that all corn in Peru is exclusively derived from corn introduced originally from Middle America into the Coastal region, to a very low level of probability.

b) The oldest complete (with attached seeds) archaeological ears of corn found thus far in Peru come from Los Cerrillos in the Ica valley. These ears are about 2,300 to 2,500 years old. In external morphology the majority are small, globular, fasciated, with brownish to reddish small kernels, irregular kernel arrangement, and have about 14 to 16 rows. Such characteristics approximate those of prehistoric ceramic ear-corn replicas found in the Sierra, those of several primitive and anciently derived Andean races, and even of Coastal races in Peru, more closely than they do any primitive or early derived race of Middle America. The plant and tassel characters of Los Cerrillos corn are also similar to those of Andean maize races, and farther removed from those of Middle American maize.

c) There are present in Peru, today, several primitive popcorn races, one of which, Confite Morocho, is as primitive or more so than any other known living race of maize.

d) Low chromosome-knob-number of the primitive popcorns and their early hybrid races, both in the Sierra and on the Coast of Peru. The knobs are conspicuous deep-staining protuberances larger than chromomeres, appearing in certain positions on the chromosomes of some species of Tripsacum, of teosinte and of certain races of maize, which have presumably experienced introgression from the former species. The widespread occurrence of low-knob-number maize races in Peru, does not wholly agree with what is known in Guatemala (Mangelsdorf and Cameron, 1942) and in Mexico (Wellhausen *et al,* 1952; Wellhausen and Prywer, 1954) concerning chromosome-knob frequency distributions at various levels of altitude. While it is true that there appears to be a progressive increase in frequency of knobs as altitudes decrease in Peru, as in Guatemala and Mexico, nevertheless, localized distributions of low-chromosome-knob numbers in certain Coastal races are quite in contrast to the general pattern.

Such races are derivations of either prehistoric Coastal races, such as Confite Iqueño, or of Highland races. On this account, prehistoric Coastal races may also be assumed to have had low knob-numbers. If knob-number is used as a criterion of teosinte introgression into maize, such races would not have experienced any contamination from teosinte-introgressed maize.

The earliest evidence of teosinte introgression into maize appears in Bat Cave corn, in New Mexico, about midway in the sequence of strata studied there, in levels that range from 2500 B.C. to 500-1000 A.D. (Mangelsdorf and Smith, 1949). This estimate places the beginning of introgression of teosinte in North America at about the time of the first known appearance of maize on the Coast of Peru, at Huaca Prieta. Since this latter maize was non-tripsacoid, three possibilities may be entertained, all of which would explain the lack of introgression of teosinte: (1) maize was carried from Middle America to the Coast of Peru so early that it missed the era of teosinte introgression in Middle America; (2) maize was brought from Middle America to the highlands of the Andean region, before the era of introgression of teosinte in Middle America, becoming established there and later appearing on the Coast; (3) independent domestication of maize took place in the central Andean Highlands.

However incomplete the cytological evidence may be, the facts already make it clear that modern Andean maize is generally derived from primitive races still present in the Andean region.

e) Different frequencies of specific genes in Peruvian and Middle American corn. As examples we may cite: (1) uniform presence of yellow endosperm in archaeological popcorns from Peru, while Mexican primitive popcorns have white endosperm; (2) high frequency of *Ga* and *I* genes, and intermediate frequency of *Pr* in Mexican and Central American corn. Peruvian corn, on the contrary, is low in *Ga* and *I* gene frequencies, and has a very high frequency of the *Pr* gene (Mangelsdorf, 1953); (3) much higher frequency of phenotypes conditioned by the presence of the alleles $A^{b'}$ and $a^{p'}$ in Peruvian than in Mexican and Central American corn.

f) Variability of maize in Peru. This provides an indication that the area is a primary center of domestication, if Vavilov's (1950) conception of the nature of primary domestication regions is followed. This conception is not generally upheld. Harlan (1956) states that it is debatable whether centers of diversity do represent centers of origin. We point out here, however, that even if it be admitted that centers of diversity may arise in the periphery of primary domestication centers, as a result of introgression or hybridization, the simultaneous appearance of primitive races and extreme genetic variability in an area may best be interpreted as evidence of the continuing prevalence of long-lasting evolutionary events that date back to the domestication of such primitive races.

THE DIVERSITY OF MAIZE IN PERU

The diversity of forms of maize in Peru has been acknowledged and referred to repeatedly by both early and recent students of this species.

Kuleshov (1929), after studying his world maize collection, decided that the greatest diversity and specialization in maize of the *amylacea* (soft endosperm) group occurred in Peru. He further stated that "the group most subdivided and richest in morphological and biological characters is *amylacea*."

The extreme variation of ecological conditions under which corn is grown in Peru, together with mutation, hybridization, and strong and purposeful selection, have resulted in the production of at least 42 races, and multiple genetic variants within each.

VARIATION IN PERICARP AND COB COLORS

Table 6A shows the variation in pericarp and cob-color gene frequencies of the races of maize in Peru, scored phenotypically on ears of typical racial collections and following the nomenclature of Emerson, Beadle, and Fraser (1936).

The colors are conditioned by the interaction of several alleles at the A_1 locus (A, $A^{b'}$ $a^{p'}$ a) and at the P locus (P^{rr}, P^{rw}, P^{cw}, P^{wr}, P^{mo}, P^{vv}, P^{or}). The *Pl* gene producing purple anthocyanin on the cob further modifies the cob phenotype, while the gene *ch*, whose phenotype is chocolate pericarp, and the gene r^{ch}, whose phenotype is cherry pericarp, introduce additional variation. Other genes modify aleurone coloration at the *C*, *Pr*, *Bn* and *R* loci. Undoubtedly still other genes contribute to a most striking variability of bizarre colors of the cobs and kernels in Peruvian maize. A wide range of shades of brown, bronze, red, pink, salmon, orange, yellow, blue, purple, cherry, and even green (by combining yellow-brown pericarp and blue aleurone) are found in kernels of the races of corn in Peru.

Two races alone, Huayleño and Ancashino, both of them with centers of distribution in the Department of Ancash, exhibit almost all the known variability in pericarp and cob-color-phenotypical combinations.

The large variability exhibited by Peruvian maize in pericarp, aleurone, endosperm, and cob colors is perhaps the characteristic which most conspicuously distinguishes it from maize of other regions. Such variability is clearly a strong argument in favor of Peru as a primary center, if not of domestication, then certainly of diversification.

A distribution of zygotic frequencies, arranged by geographical areas is presented in Table 7A. It is apparent, at once, that there are large variations in the frequency distributions of the *A* and *P* alleles in various Departments of Peru. Both Ancash and Ayacucho exhibit a higher degree of variability and a more contrasting pattern of such frequencies than the other Departments. As a matter of fact, Ancash is the world center for brown and red pericarp and cob colors. What, if any, connection there is between this fact and the very high frequency of red and brown pericarp in archaeological maize excavated in Peru is not fully realized at this time. More information on gene frequency distributions and additional data on archaeological maize at the earliest levels will be required before arriving at definite conclusions. It is apparent now that wild maize might have had a brown or red pericarp color. North American prehistoric maize, dated as contemporaneous with later Peruvian material (700 A.D.), also has brown and red pericarp colors (Anderson and Blanchard, 1942).

In general, the highland races exhibit more variability in respect to colors of cob, pericarp, aleurone and endosperm than the lowland races. Since prehistoric times the highland regions have been areas with larger human populations and more intensive agriculture than the lowlands of Peru, and its corn has exhibited a high degree of variability, associated with the diversity of its uses by the indigenous population. Even today, artificial variability is often purposefully maintained in small farm plots by mixing, at planting time, seed of all the types which may be desired for some special use, such as cherry pericarp corn (Kculli) for *chicha*, white corn for *mote*, and red or brown pericarp corn for *kcancha*. At harvest time, the different segregating types are separated for consumption, and the extreme ears of each race or type in the mixture are kept for seed.

VARIABILITY OF CYTOLOGICAL CHARACTERS

The distribution of positions and the frequency of presence of chromosome knobs and of accessory chromosomes, called B-chromosomes, in Peruvian races of maize, cover a wide range, and are racial characteristics which exhibit great variability. Highland races are generally low in chromosome-knob number, and are largely devoid of B-chromosomes. The diversity in cytological characters is treated in greater detail in a later section.

Although the basic knob positions of Andean maize (subterminal small knob on long arm of chromosome 7, and subterminal small knob on long arm of chromosome 6) predominate, all of the other knob positions previously reported are found in one or another race in Peru. The distributional patterns of frequencies of knob positions are variable and peculiar to each race.

The total number of knob positions present per cell (counting a homozygous or heterozygous knob as one) has been found to vary from zero to 14, the highest numbers occurring in plants of the race Arizona, belonging to the Mexican Tuxpeño complex. In a similar way, the number of B-chromosomes per cell varies from zero to 4, and the frequency of plants showing one or more B-chromosomes, in each race, varies from zero to 66 per cent.

VARIATION IN MORPHOLOGICAL CHARACTERS

Studies of seedling coloration of mid-vein, tip, border, and auricles of the leaf and of the coleoptile (due to poorly known alleles at the *R* locus), and leaf sheath (*Pl*, *R* and *B* factors), indicate considerable variation in the frequencies of plants with such color indicators from different geographical locations, irrespective of race.

If we consider the variability of morphological characters of plant, tassel, and ear, we encounter in Peru a wide range of racial variation. The extent of racial variability of all the morphological characters examined in this study of Peruvian maize is shown in Tables 2A to 11A.

Many of the studies of the genetic factors and mutable systems reported in the maize genetic literature of the United States were made on plants of or related to Peruvian corn races. Other factors have been noted in the course of studies which are being carried out in Peru. This list covers seedling, plant, and seed-color systems, seed textures, cytoplasmic pollen sterility (Rhoades, 1933; Grobman, 1959), mutable systems (Grobman, 1958a), etc.

The range of distribution of several of the Peruvian maize races extends beyond the actual geographical boundaries of Peru into Ecuador, Colombia, Bolivia, Chile, and Argentina. Although some additional peripheral variability appears in these countries, it is apparent that the central Andean region, considered in relation to the whole South American continent, is the area of greatest present maize variability.

Much of this variability may be interpreted as being of quite recent occurrence. It has resulted from hybridization among Peruvian races, and with exotic races. With subsequent selection, and the addition of recent introductions, the process is being continued in a relatively large aggregation of microcenters throughout Peru. This interpretation of the extant variability of maize in Peru fits the dynamic concept of "gene centers" or centers of breeding of variability, as enunciated by Harlan (1951).

In summarizing, we may state the following conclusions regarding the variability of maize in Peru:

1. The overall range of variability of maize in Peru and peripheral areas is greater than that of the other primary maize regions on the American continent.
2. Such variability points to the central Andes as a center of

active evolution of maize in both past and present times.

3. The presence of ancient indigenous forms, and the large genetic variability of maize indicate the Peruvian area as a primary domestication center for this species. Domestication was followed by large-scale hybridization, introgression, and selection. This primary center is additional to an independent primary domestication region in Middle America.

4. Most of the variability of maize in Peru can be classified into races. Borrowing from the individual definitions of Mayr (1942) and others, we may define a race as an actually or potentially interbreeding population, one of the several which may form a species distinguished by having in common certain morphological and physiological traits, and, therefore, also having in common the genes which determine these traits.

FACTORS INVOLVED IN THE EVOLUTION OF MAIZE IN PERU

ISOLATION

Genetic diversification within Mendelian populations is one of the methods whereby a given species may master a diversified environment. An alternative is the fractionation of the species into several or many reproductively more or less isolated populations (Da Cunha and Dobzhansky, 1954). A multiplicity of genotypes may be maintained in such populations, either through selective advantage of heterozygous gene combinations or else, extending a conception of Levene's (1953), through the selective advantage of each population in a particular niche in the territory.

In this connection, it is well to indicate here that Wright (1931) recognized that the breakdown of a species population into sub-populations through effective spatial isolation, and the action of mutation and selection pressures of different magnitudes on each sub-population, are conditions which lead ultimately to the greatest evolutionary changes.

The effect that isolation has played in the evolution of maize in Peru is all-important. It could well be singled out as a regulating factor for the effects of population size, genetic drift, preferential segregation, mutation, hybridization, and selection.

That the physiographic conditions and the geographical location of Peru have contributed to efficient isolation is beyond any doubt. The prevalence of maize races with low chromosome-knob numbers in the Andean region, may be taken as proof of a long-lasting isolation from knobbed maize, teosinte, and knobbed Tripsacum species.

Small inter-Andean valleys with limited cultivated areas, separated from one another by high mountain ranges, may have been responsible for the breeding of diversity in early agricultural times. In the same manner, altitudinal differences could have been very effective in conditioning the natural selection of adaptive gene complexes over small or large geographical areas. Within a single inter-Andean valley and on a single mountain slope, different genotypes would originate, variously adapted to differences in light intensity and quality, temperature patterns, water supply, physical conditions and fertility of the soil, and wind velocity. Wherever the slopes were not in continuity of cultivation, effective isolation within any growing season would occur spatially over a very short distance. If seed were saved every year under a subsistence type of agriculture, the development of physiological isolation systems based on shifts to shorter growing period genotypes at higher altitudes would take place through natural selection for adaptability.

The physiological isolation systems found in Peruvian corn are of two of the three kinds recognized by Stebbins (1950) as generally prevalent in plants:

a) Temporal or seasonal isolation, which takes the form of a genetic, potentially reduced vegetative period in corn native to higher altitudes, to compensate for the actual lengthening of its growth period due to lower mean temperatures. On the other hand, in the corn of the lowland-valley irrigated areas, there is an increase in the genotypical, controlled vegetative period and a lengthening of the duration of anthesis.

Such temporal isolation may have begun when the early popcorns were subjected to irrigation at lower mountain altitudes. There is a strong possibility that it may have proceeded in recent times in the reverse direction, that is, by development of earliness in new desirable races originating in lower altitudes and later being carried up to higher-altitude areas. This is the case, for example, in the Cuzco Amarillo race, which was brought 700 meters up from the Urubamba valley to the nearby heights of Marras, resulting in a complete change in the vegetative habit and in increased earliness.

b) Isolation by prevention of fertilization through a genetic mechanism. The presence of a dominant gametophyte factor, *Ga* on choromsome 4, in corn has been reported by Emerson (1925) and Mangelsdorf and Jones (1926), with a stronger allele Ga^s at the same locus, reported by Schwartz (1950), a second dominant factor, Ga_2 on Chromosome 5, found by Brieger (1937), and an additional *Ga* factor on chromosome 9 (Mangelsdorf, unpubl.).

This gametophyte isolating mechanism is frequently encountered in popcorn races of both North and South America (Nelson, 1952). It was found in a popcorn race, "Pisankalla" from Cochabamba, Bolivia (*ibid.*), which belongs to the same racial group with Confite Puntiagudo of Peru. It is, furthermore, present in the primitive popcorn race Confite Morocho, its derived race Morocho, and in the coastal races Perla and Arizona (Mangelsdorf, unpubl.).

The evolution of a gametophyte isolating mechanism in corn could have arisen as a barrier against hybridization between wild corn and Tripsacum. If this was the case, it must have been preceded by long geographical isolation following an initial sympatric distribution of both species, so that the frequency of the *Ga* allele could increase in the early populations, as Stebbins (1950) theorizes in general for the development of all genetic isolating mechanisms.

The presence of *Ga* in both North and South American popcorns fits this hypothesis. However, it is interesting to observe that the frequency of *Ga* in Peruvian corn is lower than in any other area (Mangelsdorf, 1953). This would mean that this isolating mechanism has been lost in Peru to a large extent, due to any of the following possible causes: stronger artificial selection and loss of selective advantage, longer period of cultivation, and absence of Tripsacum.

It is now evident that the Andean ranges and the deserts between coastal valleys in later periods were not deterrants to the migration of maize. On the contrary, during the Tiahuanaco Coastal invasion new races of corn were introduced to the Coast in mass, accompanying population movements (*mitimaes*), as the corn from La Rinconada (p. 91) and the stratigraphic sequence at Ancon (p. 89) seem to indicate.

The value of isolation in the evolution of maize in Peru must be considered in the face of the circumstances under which corn was cultivated: hundreds of ecological niches, in coastal valleys separated by deserts, on mountain slopes and plateaus, in jungle clearings and on river beaches. Undoubtedly, under this variety of conditions, from early agricultural periods, habitat-sub-population interactions and gene frequency drifts resulting from failure of crops and subsequent use of a few unselected ears, could have changed the genetic make-up of populations in the various niches considerably. Furthermore, the sizes of the isolated populations in which these changes could take place would in most instances have been very small. Such small areas with small isolated populations would also become active microcenters, contributing to the overall variability wherever hybridization and subsequent selection took place independently within them.

The variability observed in Peruvian corn must be accounted for to a large extent by the modfying effect of isolation in conditioning: (1) primary variation through selection of mutations and genetic drift in different multiple ecological habitats, and (2) secondary variation originating in some such habitats after hybridization and selection of segregating racial hybrids.

MUTATION

The conditions under which corn is grown at high altitudes in the Peruvian Andes, namely, large oscillations of temperature of over 30°C between day and night, with clear skies and weakly filtered radiation, might be propitious for the production of relatively high spontaneous mutation rates.

No detectable chromosomal abnormalities have been found in corn from Peru, with the exception of a possible abnormal chromosome 10 which is very much localized in one or two races and in one of the Central Coast valleys. As with corn from other areas, the great variability shown by maize in Peru may be explained by the accumulation of spontaneous mutations which exhibit selective advantage when in a heterozygous form.

Aside from the effect of purely extracellular mutagens, internal mutational activity has recently been recognized. The interesting studies of Rhoades (1938), McClintock (1950, 1951, 1956), Brink and Nilan (1952), Brink (1958), Peterson (1960), and others, on controlling elements and mutable systems in corn, have provided information on the existence of mechanisms responsible for stepping up recurrent mutation rates and directing the mutational activity of specific genes in this cereal.

Emmerling (1956) has reported on the considerably increased mutation rate at the *R* locus induced by the presence of a homozygous knob on chromosome 10. Mangelsdorf (1958a) has brought forward evidence of the powerful mutagenic effect of teosinte (and Tripsacum) chromosome segments introduced into maize genoms. Galinat (1960) has shown further that the mutagenic activity of teosinte chromosomes is enhanced when introduced in a heterozygous condition in inbred strain A158. The fact that the gene *Dt* responsible for directing mutation at the a_1 locus is located on or in the proximity of a terminal knob on chromosome 9 short arm is additional evidence of the same nature.

These references argue in favor of the possibility that internally induced effects on mutational activity in maize are the result of some kind of either *Zea-Tripsacum* or maize-teosinte genetic interaction.

In Peru, corn has been exposed to both external and internal mutagenic pressures. Several possible mutable systems arising in different Peruvian maize races are under study at the present time (Grobman, 1958a, and unpubl.). Phenotypic effects similar to those described by Brink and Nilan (1952) on variegation and unstable loci, by Brink (1958) on aleurone marbling, and by others on several endosperm pigmentation patterns have long been selected for and propagated for aesthetic and ceremonial purposes by Indian farmers.

Whether such controlling elements originated in Peru, or were introduced, is not yet known. There is no instance of variegated pericarp or aleurone pigmentation patterns in archaeological corn in Peru, a fact which would suggest either introduction or origin anew of internal mutagenic factors at a later date, probably with the appearance of tripsacoid corn.

Mutations must have taken place not only in genes with visible qualitative effects, but in genes of polygenic series with quantitative effects. That quantitative variation can arise in plants through mutation has been sufficiently demonstrated by Gregory (1956).

The expression of mutation can also be interpreted (Mather, 1943; Sax 1931) as the release of genetic variability outside the previous range by the occurrence of recombinations of genes with tight linkages; or the rupture of complex gene loci, as the case of the tunicate locus in corn seems to indicate. (Mangelsdorf and Galinat, 1960).

Mutation pressure alone could not explain, at the very low rates at which it is known to occur (about 10^{-6}), such profound evolutionary changes as those experienced by Peruvian corn. However, by the accumulation of many mutated genes with a possible selective advantage when heterozygous, new internal polygenic balances developed that undoubtedly differed from one valley or adaptative area to another. Thus, a large store of initial potential variability, available for further hybridization and selection, was built up in Peruvian maize.

SELECTION

For selection to be effective in producing evolutionary changes in a plant species under domestication, it is required that sufficient genetic variability be present in such a species. Genetic variability may originate through the accumulation of mutated genes, through recombination of previously linked loci, or through the introduction by hybridization of new genes, either from genetically and adaptively divergent populations of the same species, or from other species or even other genera.

Selection by itself does not create genetic variability (Lerner, 1950), but in certain cases additional variation appearing under artificial selection may be explained either by the release of previously bound genetic variability due to rare recombinations (Mather and Wigan, 1942), or by the elimination of certain major "bottleneck" genes (using A. J. Mangelsdorf's [1952] terminology) in the course of the selective process, thus enabling new genetic interactions to occur within the unmodified systems of genes, and resulting finally in the expression of transgressive or new phenotypes.

The effective limits that selection may achieve are dependent upon the original frequencies of the genes responsible for the character under selection, the mutation rates of such genes (Falconer, 1960), and the magnitude of the non-heritable or environmental fluctuations (Mather and Wigan, *ibid.*).

Domesticated plant species, besides being subjected to natural selection, are under the continuous action of artificial selection pressures. It might be conceived that artificial selection could operate at such high pressures in certain economic species as to make the level of action of natural selection appear comparatively small by contrast. In reality, however, in many species the two selective forces operate within equilibria dependent on the genetic structure of the species, the range and nature of its geographical distribution, and its genetic and ecological relationships to other species.

The directions that maize selection has followed in Peru may be grouped into the following categories: (a) selection for adaptation; (b) selection for yield improvement; (c) selection for utilitarian, ornamental, or aesthetic reasons.

SELECTION FOR ADAPTATION

Without any doubt, the greatest achievement of human selection of maize in Peru has been the extension of the range of geographical adaptation of maize to any habitat fit to support mesophytic plant life. The sub-equatorial position of the Peruvian region has enabled artificial selection to extend the cultivation of maize from sea level to an elevation of 4,000 meters. Corn is grown in Peru in desert oases, in irrigated and non-irrigated valleys, on plateaus and mountain slopes, and in clearings of subtropical and tropical rain forests, an immensely more varied assortment of environmental conditions than for any other single cultivated species.

The first major adaptive change experienced by corn was domestication proper, that is, its placement under cultivation. Several important effects may have arisen as a consequence of this. If, as it appears now, wild corn was growing in light population densities, and had both staminate and pistillate spikelets on the same inflorescence, a considerable amount of self-fertilization must have occurred. Its growth in larger population densities after domestication may have brought about an increase in the percentage of cross-fertilized seed formed, and the spread of new mutant genes, leading to morphological changes in the inflorescences and to the development of the corn ear as it is known today.

The second major adaptive change was the growing of corn under irrigation. It is likely that this development took place in the middle altitudes of the Peruvian Andes. Vavilov was ready to recognize the significance of this adaptive transformation as an event that led to significant morphological changes and accelerated evolution in Andean corn. However, the extent to which irrigation has affected the evolutionary process of corn cannot be ascertained as yet. The evolution of some maize races such as Cuzco has obviously been affected by this factor, while that of other races, particularly in more recent periods, has been rather independent of its effects.

The extension of the geographic range of maize cultivation both horizontally and vertically through a wide range of latitudes and altitudes was a third major accomplishment of artificial selection for adaptation. Maize reached the higher altitudes of the Andes and the Coast, radiating from a middle-altitude area of distribution. As its range of cultivation extended, a breakdown in its geographic distributional continuity occurred, particularly along an altitudinal axis. Corn populations were then subjected to multiple and different pressures of natural selection, interacting with fixed artificial-selection-pressure levels, producing in the end a number of morphologically, genetically, and adaptively-distinct populations. The genetic structure of such maize populations is somewhat similar in pattern of development to the ecotypic subspecies studied altitudinally in *Potentilla glandulosa* Lindl., by Clausen and Hiesey (1958). Besides characteristics pressed into these ecological races or ecotypic subspecies by artificial selection, they otherwise acquired under a large natural selection pressure differences operating in different habitats, a relatively positive adaptive response to a certain range of environments. In such ecological races, both morphological and physiological characters have a certain degree of "coherence," as suggested by Clausen and Hiesey, but not so much as to effect any substantial reduction of recombination in hybrids of inter-population crosses. This coherence of characters in maize would be maintained through selection rather than through a reduction of the rate of recombination.

The races of maize described in the present study undoubtedly arose as ecological races, but after becoming differentiated underwent, in many cases, a considerable expansion in their areas of distribution. This resulted in the maintenance of certain typical racial characteristics at low levels of variability, held there by artificial selection, while others were permitted to vary, and indeed had to vary, to allow for adaptation in the augmented geographical dispersion area. In fact, we might conceive some of our bona-fide present-day maize races as taxa made up of several ecological races. On the other hand, in times past, some less-evolved maize races might have consisted of a single ecological race. Let us make it clear here that our own distinction between a *race* and an *ecological race* as applied to maize depends only on the degree of variability. A race may be made up of one, few, or many sub-populations or ecological races.

One of the first major achievements of corn selection in the central Andes was the lowering of the ear, allowing it to be inserted on a thicker part of the stalk, to gain improved mechanical support and to be in what Mangelsdorf (1958b) considers a more favorable developmental position (Fig. 226). This selection, the result of natural and artificial forces combined, became particularly successful in the higher-elevation habitats. In most cases it was accompanied by a reduction in the height and leaf area of the corn plant, producing phenotypes better adapted to chronic drought conditions, hail damage, and low temperatures. An extreme form of such adaptation is found today in the race Confite Puneño (Fig. 67); it occurs also in Granada, Kculli and Huayleño.

In most of the lowland races enlargement of the ear was not accompanied by a lowering of position, but rather by an increase in the height of the ear above ground. This high position of the ear is positively correlated in coastal races with large leaf area (Grobman, 1953), and as the data in Table 3A show, it is conditioned solely by increase in the number of internodes below the ear. This high ear position may be an optimal condition for fitness imposed by the selective action of insects and rodents and also by its correlated character leaf area. Wherever environments favorable to full vegetative growth occur, natural selection of corn in Peru has proceeded in the direction of building tall, strong, and sometimes unusually wide stalks, as in the race Marañon, capable of holding large ears placed very high on the plant.

Ear position for higher fitness in lowland maize races, resulting largely from natural selection, and partially from artificial selection under minimal cultural practices and low population densities, does not coincide with optimal ear position in high-yielding corn selections under effective agronomic control of the environment. The latter ear position is generally much lower than the former.

SELECTION FOR YIELD

It is unquestionable that selection intended to improve yield must have been exercised from early times during the evolution of corn under domestication. The form taken by this process in Peru has generally been mass selection, based on the choice at harvest time of bigger and better-looking ears for seed.

In order to determine the real effectiveness that mass selection has had in the improvement of the yield of Peruvian maize races over a considerable period of time, the effects of hybridization must be excluded or else precisely evaluated in any study.

Data such as those presented in Tables 5 and 6 can be useful to indicate the approximate trend of increase of two yield components, ear width and ear length, over a given time period. Los Cerrillos corn (500-300 B.C.) had an average ear length of 5.7 cm. and an average ear width of 2.4 cm. in one of the oldest excavated levels. Nazca corn (1-800 A.D.) in the same area had an average ear length of 10.1 cm. and an average ear width of 2.8 cm. for the collection with the largest ears (presumably the oldest available at the Lima Anthropological Museum). Iqueño, a variety of the Chaparreño race, in the same region where Nazca and Los Cerrillos corn preceded it, is a modern development of these two

TABLE 5. Average Values for External Ear Characters of Archaeological Maize of the Coast from Different Sites and Periods.

Site and Period	*Number of Ears*	*Ear Length (cm)*	*Ear Diameter (cm)*	*Kernel Length (mm)*	*Kernel Width (mm)*	*Kernel Thickness (mm)*	*Number of Rows*
Los Cerrillos, Ica (Early Paracas)	126	6.09	2.33	4.7	4.6	4.5	16.8
Ocucaje (Early Paracas)	8	7.48	2.88	6.6	5.1	3.7	14.0
Paracas (Early to Late)	113	8.53	2.87	7.7	5.6	4.5	14.4
Nazca (Early to Late)	193	7.90	2.66	7.4	5.4	4.3	14.2
La Molina (Coast Tiahuanaco)	25	7.77	4.01	10.4	7.2	4.8	14.8
Ancon (Late)	9	10.60	4.33	11.5	8.4	5.0	14.4
Chan-Chan (Chimu)	3	10.60	3.10	10.0	8.0	—	9.3

races with an average ear length of 10.5 cm. and an average ear width of 4.3 cm.

It may be seen that a relatively large increase in ear length (4.4 cm.) took place during the span of time between the periods represented by Los Cerrillos and Nazca corn. Los Cerrillos corn was already a hybrid population, as will be shown in the next chapter, and the relatively large increase in ear length leading to Nazca corn, which approaches 77 per cent of the original Los Cerrillos corn in length, may reflect selection of a variability already present in this latter population, as a result of previous hybridization. The increase in length of ear from that of the Nazca corn to that of the present day Chaparreño race is very limited.

Looking, in retrospect, at this evolutionary trend in ear length, we may note that it conforms to the interpretation of the virtual exhaustion of large-scale variability or reduction of additive genetic variance for ear length in the Ica Valley populations during the last 1,000 years. This would account for an inefficiency of selection for ear length, in spite of hybridization of Nazca corn with the Andean race Proto-Chullpi, which came to the Coast at the time of the Tiahuanaco intrusion. Proto-Chullpi, apparently did not contribute major ear-length genetic components, but did contribute components for ear diameter, which are manifest in the increased diameter of the ears of Chaparreño.

Chaparreño ear length may be compared, on the other hand, with average ear length of all coastal Peruvian races taken as an index of their evolutionary progress at the present time. Extensive hybridization, even with exotic races, has proceeded to form these races after the Nazca Period. It is evident that the added variability contributed by this hybridization in the last 1,000 years has allowed a continuation during this last span of time of the same rate of evolution of maize ear length on the Peruvian Coast as in the previous 1,500 years (Fig. 18).

Meanwhile, races which did not become involved in hybridization with other exotic or phylogenetically remote races, such as was the case with Chaparreño, of the South Coast and Mochero of the North Coast, experienced a very limited change in ear length. This limited change is entirely ascribable to the ineffectiveness of artificial selection, which had already depleted the main original variability for ear length. This original variability

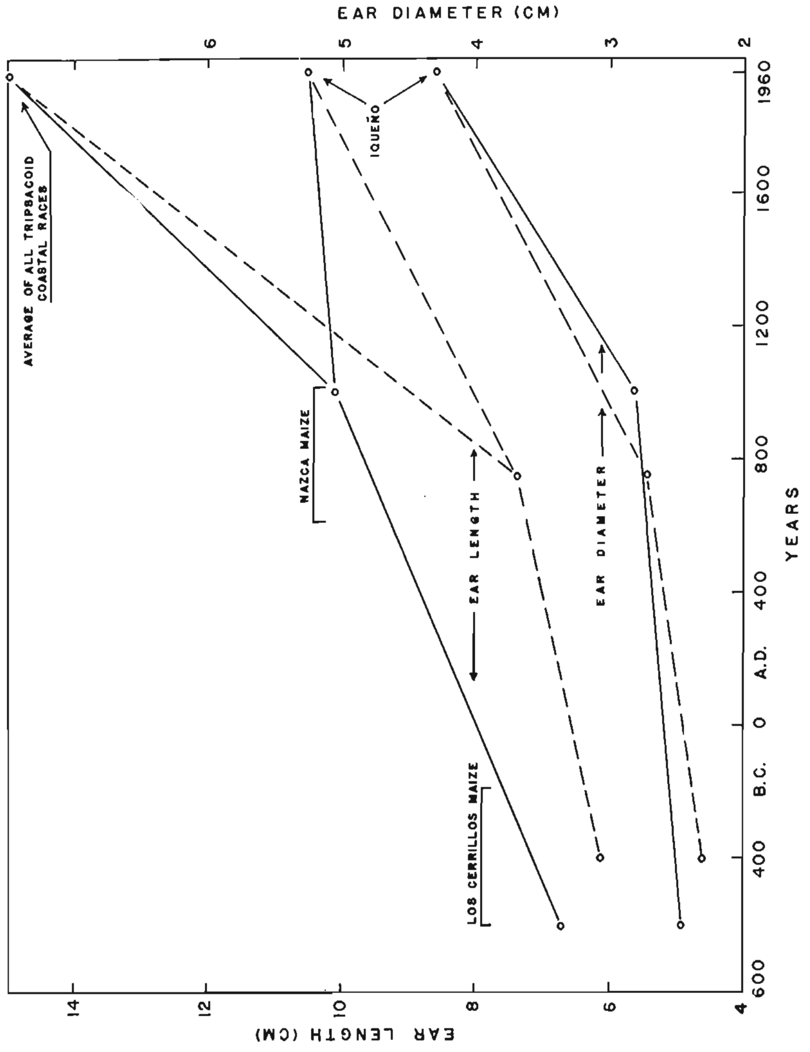


FIG. 18. Evolution of ear length and ear diameter of maize of the Ica region, South Coast, during the last 2,500 years. The curves with continuous lines correspond to the increase in dimensions of the extreme collections (the smaller and older in Los Cerrillos, and the larger and presumably later in Nazca maize). The curves with broken lines correspond to the average values of all the collections from each period. Increase in length of ear paralleled increase in ear diameter until the Nazca period. Hybridization with Chullpi, a Sierra maize, increased diameter but did not affect length of ear, as evidenced in Iqueño maize. An accelerated evolution in ear length after the Nazca Period is evident in the tripsacoid Coastal races. The average ear diameter of the tripsacoid Coastal races coincides with that of Iqueño.

was due to the hybridization of primitive popcorns preceding the Early Paracas Period (before 500 B.C.).

The fact that the present-day tripsacoid maize races of the Peruvian Coast as a group have longer ears, is of added significance (Fig. 18). The implications of this situation will be followed up in the next section.

An alternative explanation for the lack of increase in ear length in Ica Valley corn during the last 1,000 years could be arrived at by postulating a limitation set by natural selection forces on plant and ear sizes, to conform to the scarce water supply of the Ica Valley irrigation system. It appears plausible that both this natural selection force imposing an environmental limitation, and the fixation of genes contributing to ear length under persistent mass selection, may have worked together against the success of artificial selection for ear length. It is improbable that even a shift of direction of artificial selection towards a multi-eared condition could have been responsible to any great extent for the conservatism of ear length in these populations.

It is apparent from the data on ear diameter that the development of this factor differed from that of length of ear. A greater increase of ear diameter occurred in the time lapse between the Nazca Period corn and modern Iqueño corn than in the nearly 1,000 years separating Los Cerrillos corn from Nazca corn. As the Nazca populations of the race Confite Iqueño hybridized with the race Proto-Chullpi, the latter contributed genes for greater ear diameter, which provided a more ample base for selection in such a direction. Hence, the effectiveness of improvement in this character may be due to the variability made available by hybridization.

The following significant conclusions on the evolution of maize in Peru relating to yield may be drawn from these preliminary data: (1) selection for yield has made progress only when it followed hybridization between races, and when it utilized the increased ensuing variability; (2) heritability of maize ear length and diameter, shown to be low by Robinson *et al* (1949) in segregating F_2 populations of prolific single crosses, is, however, of variable intensity in different corn varieties, depending on their past history of exposure to hybridization and selection; (3) the larger variability following hybridization can be accounted for on the basis of the increase in number of loci with intermediate frequencies of alleles becoming active in the F_1 and affecting the variances of the yield components in advanced generations.

SELECTION FOR SPECIFIC UTILIZATION, ORNAMENTAL, OR AESTHETIC PURPOSES

The most striking features achieved by selection for ear type in Andean corn races were quite different from those achieved in Mexico. The ears of most of the Peruvian-derived races have: (a) large floury kernels, (b) relatively low row numbers, (c) extremely large shelling percentage, which in Cuzco Gigante reaches the amazing figure of 95 per cent, and (d) easy shelling. In all these traits racial extremes are to be found in the Peruvian region of the Andes.

Undoubtedly, active genetic mechanisms have been in operation in Andean maize to condition increase of endosperm size. Whether such systems operated independently or were negatively correlated with systems conditioning heterosis in row number is not known. Split pericarp has been observed as a segregating character in ears of archaeological maize of pre-Pueblo Indians from the southwestern United States (Collins, 1923), as well as in Peruvian archaeological maize. In both areas such seeds with ruptured pericarps may be indications of the effect of xenia or heterosis in the F_1 generation for endosperm size. This effect can and should be distinguished, at least in Peruvian maize, from a broken pericarp character, caused by a single gene (Zapparoli, 1925). It is typical of characters affected by few genes, and if it arose in Andean corn at an early time it would certainly have been easily selected and propagated, as it represented new possibilities for the use of corn. Such larger kernels would have contained more starch in relation to protein, and could have been eaten roasted instead of popped. They would keep longer, were softer to chew, and would also have served for *chicha* or corn beer. The trend for selection of large kernels attained its maximum expression with Cuzco Gigante, the race of maize which exhibits the largest known kernels in the species.

There is no doubt that considerable selection pressure has been exercised to keep the various races with utilitarian specialization in a rather pure form. Such races as the popcorns, the sweet corn Chullpi, the black corn Kculli, the *kcancha* or roast corn Huayleño, and several others have been maintained as separate races because of their special usefulness.

Corn ears with attractive pericarp, aleurone, and endosperm color patterns have been selected for ornamental purposes in the homes of the Indian farmers. In one instance—the race Pisccorunto—the particular sweetness of the roasted ear is considered to be the motive for the selection of spotted blue aleurone kernels.

Abnormal characters are in some instances preserved by selection, whenever they have been subject to mystical or religious interpretations. One such character is branched ear, which is called *tacce* (Takje) in Quechua. These ears are prized by Indian farmers as charms to aid in promoting the fecundity of their families and that of the earth; they are modern relices of the *zaramamas* or good luck charms of Inca times (Acosta, Arriaga, Calancha). A few kernels are reserved for planting every season.

HYBRIDIZATION

In previously published studies on the races of maize in several geographical areas, (Wellhausen *et al*, 1952; Roberts *et al*, 1957; Wellhausen *et al*, 1957), the role played by hybridization in the development of new races has been given considerable attention.

It has been shown by Mangelsdorf (1952) that the advanced-generation hybrids of interracial crosses theoretically could, and in fact appear to, retain a considerable proportion of the yield gained in heterosis. Recent experimental data (Moll *et al*, 1960) give evidence of an increase in variability in the F_3 generation of a cross of two open pollinated varieties, compared to that of its parents, with retention of higher yield than the parental means.

The formation of new races may follow from the hybridization of parental races, which have enough genetic diversity to bring about heterosis and increased variability in their progeny. Artificial and natural selection would then readily fix the genes responsible for the visible traits accounting for the distinctiveness of the race, as well as those characters that have to do with adaptation to a particular set of environmental conditions. It is not obvious, however, that fixation of genes responsible for polygenically controlled traits would occur in the new racial hybrids. Certain gene combinations may be kept in heterozygous condition, which would create overdominance heterosis and thus be of selective advantage.

Mangelsdorf (1952) has suggested that natural selection (operating in a man-made environment) would tend to preserve a heterozygous race. Repeated cases of the selective advantage of heterozygotes have appeared in the literature. Lerner (1954) has given ample support to this view on genetic grounds, and Haldane (1954) has considered it reasonable in the light of biochemical considerations of gene action.

It appears that hybridization has been the major factor responsible for variation in Peruvian maize, and for the development of the derived races. Its full effects did not come into the evolutionary pattern of Peruvian corn until widespread migration, concomitant with the building of empires, commerce, and wars had taken place; in other words, during the latter periods of the evolution of organized societies in the Andes.

We may place the era of hybridization in Peru approximately between 500 and 1000 A.D. This does not mean that hybridization did not take place earlier. Actually, the corn from Huaca Prieta and Los Cerrillos provides evidence that incipient hybridization had occurred, at least between two primitive popcorn races, Confite Iqueño and Proto Confite Morocho. It does mean, however, that not until some of the early hybrid races had been formed by the selection of accumulated forward mutations and by the selection of desirable segregates of early interracial crosses, and not until these races had acquired sufficient genetic diversity from one another, could potent and permanent heterotic effects be achieved.

Maize is unique among cultivated plants in its heterotic system. Yield heterosis in modern corn could be thought of as having five major components:

1. *Intra-maize (maize x maize) heterosis.* This is present in interracial crosses of non-tripsacoid maize. Such crosses among non-tripsacoid maize races of the Peruvian Sierra produce F_1's which exhibit large yield heterosis, exceeding in some cases the mean yield of their parents by as much as 50 per cent.

2. *Intra-Tripsacum (Tripsacum x Tripsacum) heterosis.* This has been demonstrated in the expression of vegetative characters in F_1 plants of the crosses *Tripsacum dactyloides* (2n) x *T. latifolium* (4n), and of *T. dactyloides* (4n) x *T. latifolium* (4n) (Mangelsdorf and Reeves, 1939). It is conceivable that tripsacoid races of maize, which have a history of past introgression of different *Tripsacum* species, should exhibit heterosis when crossed, due in part to the heterotic effect between their Tripsacum

genetic components. The hypothetical Tripsacum x Tripsacum heterosis components of a Peruvian maize race are shown in Fig. 237.

3. *Maize x Tripsacum heterosis.* This is evidenced today in a relic form in the products of Tripsacum introgression into maize, among them the tripsacoid races of the South American lowlands, i.e. Enano, Piricinco. More evolved maize races to which Tripsacum germplasm has presumably been transferred, such as Ancashino, give higher average levels of yield in hybrids with non-tripsacoid races than the average heterosis level of hybrids among non-tripsacoid races.

4. *Tripsacum x teosinte heterosis.* It would follow from points 2 and 3 above that heterosis ought to be present in Tripsacum x teosinte crosses, if it is accepted that teosinte originated as a hybrid between maize and Tripsacum as postulated by Mangelsdorf and Reeves (1939).

5. *Maize x teosinte heterosis.* Teosinte has been shown to be effective in increasing ear length and its variability in advanced generations of what appear to be maize-teosinte hybrids, in archaeological maize from Arizona (Galinat *et al,* 1956) and from Cebollita Cave, New Mexico (Galinat and Ruppe, 1961). Some lines derived from maize x teosinte crosses by Reeves (1950) were more heat-resistant and produced higher-yielding hybrids than their parental lines.

Only the first three of these components of heterosis are applicable in general to the native maize of Peru. The last two components have started to operate only recently in hybridization with modern introductions from the Middle American region.

THE ROLE OF TRIPSACUM

No wild Tripsacum species or teosinte have ever been reported in the central Andean area. *Tripsacum australe,* however, was described by Cutler and Anderson (1941) as a new species, growing wild, with a geographical distribution comprising the following countries: Bolivia, lowlands and up to 1,500 meters above sea level; Brazil, lowlands; British Guiana (Kanuku mountains); lowlands and low hillsides, below 800 meters; Ecuador up to 1,200 meters; Paraguay, south to latitude 26° S; Venezuela, in savannas and slopes of the southern Sierra de Amambay.

Tripsacum australe from Brazil was examined cytologically by Graner and Addison (1944) and found to have knobless chromosomes. On the other hand a Colombian Tripsacum placed within *T. australe* and examined cytologically by Ting (1960) had several knobs.

In view of this distribution of *T. australe* both to the north and south of Peru, it may be that future explorations in the Amazonian Basin lowlands or on the eastern Andean slopes will disclose its presence in Peru.

Even if *T. australe* is eventually proven to be definitely absent from the Peruvian region, still its influence on Peruvian corn may be postulated as the result of centripetal gene flow to the nuclear Andean populations, after hybridization of maize and Tripsacum had taken place in the periphery of the central Andean region.

After equilibrium had been attained in the nuclear Andean maize populations, centrifugal radiation of Andean corn carrying *T. australe* genes occurred. This secondary gene flow went into the maize races of the lowlands of South America, into the maize of the highlands of countries north of Peru, and was ultimately carried as far away as Central America and Mexico where it affected the maize races of those regions.

That such Tripsacum introgression into maize may have taken place directly through intergeneric hybridization of maize and *T. australe* in the periphery of the central Andes is supported by the following evidence: (a) native tripsacoid maize races of the central South American region have a low number of chromosome knobs, as would be expected if their tripsacoid characters had been contributed by *T. australe;* (b) a number of tripsacoid maize races (which do not have any sympatric range with teosinte and could not have received their tripsacoid characters from this species) have been described from countries in the periphery of the Peruvian Andean region, such as Chococeño in Colombia (Roberts *et al,* 1957); races of the Piricinco (Coroico) and Enano groups in Brazil, Bolivia (Brieger *et al,* 1958; and Ramirez *et al,* 1960) and Peru; and Maiz Amargo in Argentina (Rosbaco, 1951); (c) chromosomes producing tripsacoid effects have been extracted from maize races of Brazil, Bolivia, Paraguay, and Argentina (Mangelsdorf and Reeves, 1959). Such tripsacoid effects are similar to those obtained by extracted teosinte chromosomes on a uniform genetic background. They are: (a) mutagenic effects such as reported by Mangelsdorf (1958a) for extracted teosinte and Tripsacum chromosomes, (b) external morphological effects on the ears, and (c) internal morphological effects on the cob structure, the latter reported by Sehgal (1961).

Examples from many hybridizations of maize races with various degrees of Tripsacum or teosinte introgression, too numerous to cite here, provide additional circumstantial evidence for the existence of interspecific and intergeneric residual heterosis in modern corn.

The observed vigor and high general combining ability of tripsacoid maize races might be due to: (a) blocks of genes from Tripsacum having higher mean heterotic effect than homologous corn genes in crosses with corn, (b) addition of new plus genes for yield components to previously existing corn polygenic series, either as new dominant alleles coming directly from Tripsacum or teosinte, as heterozygous, nonallelic, newly inserted minute segments within corn chromosomes; or more plausibly, (c) as controllers or shifters of action of whole blocks of pleiotropic maize genes (switch genes), thereby increasing the number of effective loci. The increase in number of effective loci would also increase variability, and hence extend the range of potential response to selection.

Most highland and some lowland races in Peru have evolved through selection after the operation in intra-maize or intraspecific heterosis. Most of the races from the eastern Andean region give evidence of heterosis and increase in variability arising from introgression of *Tripsacum australe* into corn. A few Coastal races with some ancestry traceable in origin to Central America or northern South America are good examples of heterotic racial interaction between teosinte-introgressed maize and non-tripsacoid Andean maize. In several races, in addition to the former two types of interaction, residual heterosis resulting from interaction of South American and North American Tripsacum germplasm incorporated in the respective parental races may be present.

THE STABILIZATION OF RACES AFTER HYBRIDIZATION

A comparative examination of biometrical measurements of plant, tassel, and ear characters of the various derived races with their postulated parental races seldom shows the former as perfect intermediates between the latter. Very often, in most plant and tassel traits there is a definite tendency for a hybrid race to approach one of the parents much more closely than the other.

In some cases ear characters follow this pattern, while in others they are more apt to be intermediate between their parents. This situation may be interpreted as stemming from the hybridization of a territorial, recurrent race with a few individuals of a migrating race, and successive backcrossing to the recurrent race, with selection for the heterozygotes, whenever they exhibited a higher yielding, desirable new ear phenotype. Selection was alternatively made for an improved recurrent parent-like ear phenotype, if it was the most desirable.

It appears that in the process of artificial selection for ear type and yield following hybridization, as new races and sub-races assumed definite standing, natural selection did not relax and continued to operate primarily on the plant and tassel architecture. Under similar environmental conditions, races widely different in genetic background exhibit plant and tassel types which look very much alike. This situation may be extended to distributions of zygotic gene frequencies which appear to be differentiated as much by geographical areas as by races (Grobman, 1957), as well as to frequency distributions of chromosome knobs which, according to observations of McClintock (1959), appear to be regulated by geographical location as much as by racial classification.

In most cases it may be assumed that similiarities between plant types of races in a given region are the result of initial hybridization between races, followed by strong natural selection for the best adapted types within each population. It is conceivable that the different races within a single habitat are undergoing convergent evolution for basic adaptive characteristics, with artificial selection for ear type operating within limitations set by the environment and by natural selection pressure.

Pertinent examples are: (a) the short tassel peduncle of Coastal races, and the long tassel peduncle of Sierra races, (b) limited vegetative development and low ear position of Sierra races, (c) tall plants and high ear position and lateness of races from intermediate altitudes of the eastern Andean areas.

Undoubtedly, considerable interracial hybridization has taken place and continues to operate today in Peru. Whenever several races have been found to be sympatric in a given region, a cline (continuous gradation) in ear types and plant characters from one to another is present.

THE PREHISTORIC MAIZE OF PERU

PREHISTORIC MAIZE A KEY TO CLASSIFICATION

The extremely large variation of modern maize in Peru made it quite apparent from the very outset of our studies that only through an integrated approach, in which a survey of archaeological corn material was given preeminence, could we hope to succeed in obtaining an accurate and complete classification of the races of maize in that country.

The use of archaeological maize material has allowed us, in some cases where we found modern races to be on the verge of extinction, to identify them accurately and to trace what we think is their correct phylogeny. Relationships among races within and between given regions, such as the Coast and the Sierra, have been clarified as a result of finding precursors of the modern races in the prehistoric maize.

The abundance of archaeological material in many cases filled in gaps in the knowledge of the origin and evolution of the maize races, and reduced the necessity of using the less efficient method of hybridizing modern races for purposes of studying their ancestry. The presence of ancestral races as actual ears or moldings on clay, over extensive periods of time and at definite locations, has been most useful in relating them to the modern maize races. Reciprocally, by comparison with modern races we have been able to identify races of maize that were grown in the past. In many instances we were able even to follow them through time and in their migrations with the peoples who grew them. The implications attached to the spatial and temporal changes of corn in these latter studies may be of particular interest to the anthropologist as much as to the geneticist and the botanist.

The unusually dry climate prevailing in the Coastal region of Peru, where the average yearly precipitation does not exceed 20 cm., has been responsible for an extremely effective preservation of cultivated plant remains for hundreds and even thousands of years. On the North Coast, short but heavy rainfall periods have been recorded approximately every 25 years; but on the Central and South Coast, not even these occasional rainy periods occur, affording some of the best conditions found anywhere in the world for the perfect preservation of archaeological remains.

Digging sites with these climatic conditions are relished by the professional archaeologists, and, indeed, they have not been disappointing to them, if the thousands of ceramic, metal, stone, textile and vegetal pieces on display in scores of museums and private collections are any measure of their success.

In the Sierra and Montaña regions, the abundance and continuity of rainfall have not helped the preservation of plant material. Consequently, much of the source material available on prehistoric maize and other plants in the Peruvian highlands comes only indirectly as ceramic replicas, which will be discussed in the next section.

Maize was undoubtedly the basic staple food of the Coastal cultural groups, as it was also in the Sierra. Although in the Sierra potatoes were next to corn in importance, they were never introduced into the folklore and into ceremonial and religious customs to anywhere near the same extent as was corn.

The knowledge we may gain about the cultivation of the maize plant from the beginning of prehistoric agriculture in Peru up to the present, from genetical, morphological and ethnobotanical points of view, will materially contribute to our understanding of how the evolution of this cereal has proceeded under cultivation. Its historic-cultural relationships (since maize may be used as an effective indicator in anthropological-sequential-dispersal studies) may also shed light on the subject of its botanical origin and affinities.

Not less important, our study of archaeological corn material, resulting in the establishment of evolutionary sequences, paths, procedures, and phylogenetic relationships by projection to modern situations may serve to provide the needed background for designing breeding methods leading towards an "accelerated directed evolution" fitted to the achievement of the breeders ideal types.

In the next sections we shall describe and discuss, in general, the archaeological maize material found in Peru, but only insofar as it will contribute to our understanding of the evolution and diversification of this cereal in the central Andes.

LITERATURE REFERENCES ON PREHISTORIC MAIZE IN PERU

Historically, the first references to maize grown in Peru come *from the Spanish Conquerors.* Hernando Pizarro, in 1533, in his letters to the "Audiencia de Santo Domingo" (*Vide* Yacovleff and Herrera, 1934), was one of the first to report on maize in Peru. The Spanish Conquistadores tell of having seen corn plants as tall as soldiers' pikes growing along the coast of the Guayaquil Gulf and Tumbes in northern Peru, when they first landed there in 1527.

The Spanish chroniclers, starting as early as 1533 and writing through the 16th Century and early part of the 17th Century, contributed abundantly to our knowledge of maize cultivation in historical times, that is, from the nearly one hundred years preceding the Spanish conquest to the post-colonial periods immediately following the conquest.

Acosta (1590), Avila (1608, 1939), Calancha (1638, 1653), Cieza de Leon (1533), Cobo (1653), Garcilaso de la Vega, Inca, (1609, 1617), Lopez de Jerez (1534), Lopez de Velazco (1894, publication date), Monardes (1569), Oviedo (1535, 1851-1855), Polo de Ondegardo (1585), Guaman Poma (1613, 1936), and Valverde (1865), reported on the uses, cultivation, dispersal, and customs associated with the growing of maize and the importance of this cereal in the economy of the Peruvian pre-Columbian civilizations.

The first recorded description of archaeological maize from Peru in modern times comes from Darwin (1851), who found what he called "heads of indian corn" mixed with shells on an elevated ledge on San Lorenzo Island, a few miles off the coast of Peru and near the port of Callao. It is known that corn ears have been found in the process of exploiting the rich guano deposits in other islands of the Peruvian littoral, since the middle of the last century, but no detailed descriptions are available on the maize thus obtained.

It was not until Reiss and Stübel undertook the task of studying and describing (1880-1887) the Necropolis of Ancon on the Central Coast, assigning the ethnobotanical part of the studies to L. Wittmack, that any formal knowledge began to accumulate concerning the Peruvian prehistoric cultivated plants, including maize.

In volume 3 of Reiss and Stübel's (1880-1887) publication, Wittmack presented a classification of the corn found in the Ancon burials on the basis of the external morphology of the ears. He recognized the following "subspecies": (1) *Zea mays* *vulgata*, or common maize, having regularly rowed or irregularly arranged round kernels; (2) *Zea mays peruviana*, with short ears and pointed or beaked, compressed kernels; (3) *Zea mays umbilicata*, distinctly umbilicate, or having a slight groove or depression on the upper surface of the kernel. Wittmack (1888) indicated that the *Peruviana* type "is the most frequent and typical" in Ancon, and he also pointed out that he had transition types between his three described subspecies. He also identified four kernels of "blue-black" maize and "maize bread," small, round, and flat in form. He could not find a true dent type, although his *umbilicata* approaches it. He had in mind as a type for comparison the "horsetooth" dent with long ears, so he assigned a great deal of importance to relative ear size, and the shape of kernels in upper-view external appearance (round or angular vs. flat-rectangular) in deciding whether a corn ear was to be classified as "dent corn" or not.

Later, Rochebrune (1879), Costantin and Bois (1910), and Harms (1922) made additional contributions to the study of maize from Central Peruvian Coast sites, especially from Pachacamac and Chuquitanta, adding little materially, however, to Wittmack's observations.

Yacovleff and Herrera (1934) described prehistoric ears of corn from Nazca, Paracas Cavernas, and the Chillon valley, giving measurements on length, width, number of rows, etc. They also supplied a key to all ear-corn shapes found in the samples they studied.

None of the original material used by the previously mentioned workers is available at this time for reappraisal in the present study. The data from Yacovleff and Herrera, together with their keys to shape, have been used to a limited extent to complement the data presented in this publication.

The only recently published detailed studies on prehistoric Peruvian corn which we may cite are those of Mangelsdorf (1942) and the series of papers by Towle (1948, 1952a, 1952b, 1954, 1956) on the plant material obtained from several sites along the Peruvian Coast during recent explorations made by Strong, Evans, and Willey. Work is in progress at Harvard University (Mangelsdorf, unpublished) on pre-ceramic corn from Huarmey, a valley of the Central Peruvian coast; also at the Missouri Botanical Garden (Cutler, unpublished) on corn obtained at the Huaca

Prieta site on the North Coast by Junius Bird (Bennett and Bird, 1949, pp. 116-123); and on corn from South Coast and Central Coast sites, obtained by G. Vescelius, D. Menzel, D. Wallace, and by staff members of the Cooperative Corn Research Program of Universidad Agraria, (formerly, Escuela Nacional de Agricultura), La Molina, Peru, at the latter institution.

CHARACTERS USED IN THE DESCRIPTION OF PREHISTORIC MAIZE MATERIAL

Archaeological ears, whether actual or molded on clay, were studied primarily for their external morphology. Internal ear characters were measured on those already broken. Kernel characters were measured when possible, preferably on the ears. In some cases, when only shelled cobs were present, the determinations of kernel characters were made on kernels found near the cobs, at the archaeological site.

Length of ear was taken on the complete cobs with a graduated sliding device which was read with the cob or ear firmly pressed between a fixed and a movable surface. When the cobs were broken, this is indicated. Width of ear was taken midway through the length of the ear with calipers.

Kernel dimensions were taken on 10 or five kernels contiguous on the same row on the middle part of the ear. Shank thickness was measured with calipers.

Internal measurements were taken with calipers on the cob rachis and pith, and related in the indices cob/rachis and cob/pith, which express the ratios of their respective diameters in mm.

Number of rows, number of kernels per row, color of pericarp of the kernel, and presence of staminate tip on the ear were the other characters scored.

DESCRIPTION OF PREHISTORIC MAIZE

SOUTH COAST

1. *Los Cerrillos*

An abundant collection of maize ears and vegetative and tassel parts was made available for study at the Universidad Agraria of Peru by Dr. Dwight Wallace (previously of the University of California, now of the University of Georgia). This material originated at the Los Cerrillos site, in the Ica Valley on the South Coast, and was found as filling material under the adobe floor of a small building located on a hillside. Corn stalks were packed on the hillside between layers of adobe bricks forming an artificial platform. This provided unusually good conditions for preservation of the stalks, husks and tassels. A cache of 78 corn ears was found under the building floor, and additional ears, all in a perfect state of preservation, including silks, husks, and kernels, were obtained from stratigraphic collections made first by Dr. Wallace, and later by him and the senior author.

The age of this corn was estimated to be between 2,300 and 2,500 years (by pottery association), placing it in an early Paracas chronological level.

We were able to reconstruct the plants as being approximately 1.40 meters tall, with a slender stalk, basal internode widths from nine to 13 mm., on which there were from nine to 11 short, narrow leaves, and one small ear at approximately 0.40 meters from the ground. The main stalk had only occasional small, unfruitful tillers, and no prop roots. The leaves were very thin, almost glabrous, with a few long, soft hairs, an inconspicuous mid-rib and smooth margins with a few tiny prickles. The leaf sheaths were completely glabrous or had very short hairs; in our archaeological material even the hairs around the upper margins

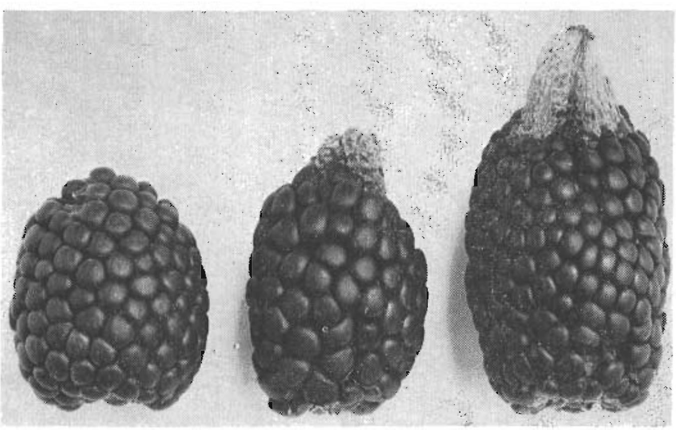


FIG. 19. Ears of the popcorn Confite Iqueño, estimated to be 2,300-2,500 years old; from Los Cerrillos archaeological site, Ica. This race is the precursor of the Early Floury maize races of the coast of Peru.

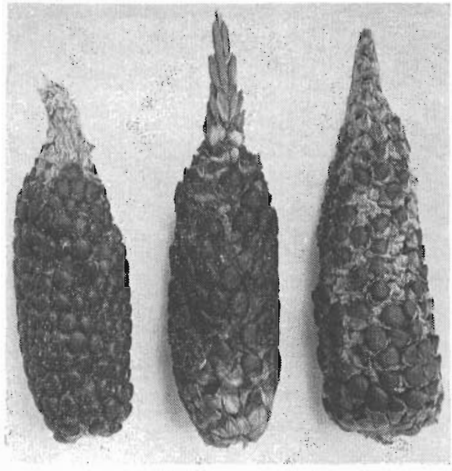


FIG. 20. Prehistoric ears exhibiting characters of Proto-Kculli and Proto-Confite Morocho. They belong to a segregating population of maize at Los Cerrillos, Ica (500-300 B.C.). These ears were longer, had longer glumes, cherry pericarp, and more developed staminate tips than Confite Iqueño, shown in the previous Figure.

of the sheath were few or almost absent. One intact sheath seems to have had none.

In general appearance these plants resembled very closely the presently cultivated plants of the anciently derived coastal group races, especially Mochero and Chaparreño. The silks were flat and thinner, and had apparently fewer hairs than modern corn silks. The husks were of a rather soft texture, with pronounced parallel venation. They were glabrous on the external surface, but had fine hairs on the inner surface. The husks varied in length between 9.5 and 16 cm., with a mean of 12 cm., and extended for 3 to 9 cm. over and beyond the tip of the ear. Most of the observed ear damage came from lateral borings of insects through the husks, not by way of the opening of the husk enclosure above the ear.

The ears (Fig. 19) were short, almost spherical, with evident fasciation in most of them. A few, to which we shall refer again later, were rather long in proportion to their width (Fig. 20).

The ears varied in length from 2.0 to 9.0 cm., with an average of 5.66 cm.; a terminal tip zone of 0.5 to 1.5 cm. was not filled out in most cases. The ears, being fasciated, had both maximum and minimum width axes, approaching elliptical shape when seen in cross section. The maximum center ear width averaged 2.44 cm., the minimum center ear width averaged 2.24 cm. The shank was slender, its diameter averaging 0.77 cm. About 13 per cent of the ears had staminate tips.

The kernels were arranged irregularly in the equivalent of approximately 12 to 24 rows, with a mean of 16.8 rows. Their shape was round, and they were almost isodiametric, with an average length of 4.7 mm., average width of 4.6 mm., and average thickness of 4.5 mm. Their texture was horny (popcorn) and they had mostly brown, red, or, in a few instances, cherry pericarp color. The endosperm color was yellow. Imbrication was absent or slight. The kernels exhibited medium to strong surface striations.

Four ears in this collection were longer and tapering, and had a cherry pericarp color. Two of these had long glumes and missing kernels; two were imbricated.

Two basic races may be recognized in the Los Cerrillos population. The first, which agrees with the general plant, ear, and tassel description given above for the spherical-eared corn, is being named Confite Iqueño, because it was found in the Department of Ica in its best preserved state, and was a popcorn (the term *Confite* is used in Peru for the popcorns) (Fig. 19). Segregating in this population is a second type of less frequent occurrence characterized by ears with a greater length/width ratio, and which are more often than not imbricated, with missing kernels, a staminate tip and cherry pericarp (Fig. 20). Since no such race is known at the present time we have not given it a distinctive name. Some of the characters listed above may be due to recombinations of genes possessed by two of the primitive races, Confite Morocho and Proto-Kculli.

An evolutionary sequence comprising perhaps 300 to 500 years for Los Cerrillos corn is shown in Table 6. From the lowest level to the upper and most recent level, the average ear length increased from 4.9 cm., to 8.0 cm., and the average ear diameter increased from 1.8 to 2.6 cm.

The evolutionary interpretation of this apparently interracial hybrid Ica population of corn, was presented in full in the preceding chapter (see pp. 61-63).

2. *Paracas*

The Paracas cultural period on the South Coast is placed in the Formative Epoch, and is divided according to pottery styles and sites into Early, Middle, and Late Paracas (Willey, 1949). Recent radiocarbon dates for Late Paracas (Strong, 1957) assign this period to between 120 B.C. and 250 A.D. The Early and Middle Periods are estimated accordingly as dating as far back as 500 B.C.

TABLE 6. Evolution of Ear Dimensions of Confite Iqueño over a Period of 300 to 500 Years at Los Cerrillos, Ica.

Stratum	*Dr. D. Wallace's Key*	*Length (cm)*	*Diameter (cm)*
1. Most Recent	3A 2 5	7.6	2.5
2.	3A 6 8	8.0	2.6
3.	1A 3	6.4	1.9
	1A 4 5	5.7	2.0
4. Oldest	2B 5 9	6.8	2.0

Data are presented by Yacovleff and Herrera (1934) for a few ears of corn from Paracas Cavernas (Early Paracas), slightly later than or contemporaneous with Los Cerrillos corn. These ears ranged in length from 7.6 to 14 cm., 3.2 to 4.1 cm. in width, 12 to 18 in row number, 7 to 12 mm. in kernel length, and 4 to 6 mm. in kernel width.

Eighteen additional identified collections of Paracas maize, comprising 118 ears from old excavations, have been studied by the author at the Museum of Anthropology in Lima.

These ears varied in average length per collection from 5.3 to 13.7 cm.; in average diameter from 2.40 to 4.32 cm.; in average kernel length per collection from 5.6 to 11.3 mm.; in average kernel width from 3.8 to 5.7 mm.; and in average kernel thickness from 4.6 to 8.3 mm. Imbrication and denting varied from none to slight; the rows were mostly irregular and very frequently 14 to 16 in number; the cob/rachis index ranged from 1.85 to 2.76.

The cupules were either deep alveolar (pocket-like) or transversely V-shaped. The sample of ears studied was almost evenly divided between these two types. About 13 per cent of the ears had rather long cupules. As the ears become longer, the transverse, compressed type of cupule tends to change to a boat-shaped elongate type. This latter type is believed to approach more closely the presumed wild form characteristic of pre-agricultural maize (Fig. 49).

In the bulk of the collections the pericarp color distribution was 12 per cent brownish-red, 67 per cent red or brown and 21 per cent cherry. In the collection which had the smallest ears and the general characteristics of more primitive corn, the proportion was six per cent cherry with all the rest red or brown.

In general, the rachis texture was soft; glume venation was weak to moderate; glume hairs were sparse, and cupule hairs few to intermediate; the diameter of the shank was small, eight to 10 mm.

Undoubtedly these collections represent an extensive period of time from Early Paracas to Late Paracas chronological levels. Several of them resemble extraordinarily the Los Cerrillos corn, both in population composition and in individual ear morphology. The race Confite Iqueño is dominant in both Paracas levels as judged by the frequency with which characteristic ears appear in the collections studied thus far. Next to it in abundance in the mixed population is a racial type, Proto-Confite Morocho, similar to Confite Morocho and intergrading into Confite Iqueño.

A straight-rowed, longer-eared racial type which could be thought of as an early, reduced version of the race Perla can be recognized next. This form blends into a additional race, closely resembling it, a Proto-Alazan type, which, nevertheless, appears to be represented by only three ears in our collections. These ears that approach the race Alazan morphologically are probably of a later Paracas Period. They also have distinct rowing, and different kernel dimensions, shape and texture, and are more like their present-day counterparts. These are undoubtedly newer phenotypes.

One ear in these collections resembles a small, floury, Chullpi type, like the present-day race Chaparreño, and another is very much like Pagaladroga, although this last one could be considered as being a segregate from a cross between proto-forms of Confite Iqueño and Confite Morocho.

Several ears exhibit kernels with overgrown endosperms and ruptured pericarps. This phenomenon is found today with relatively high frequency in ears of the race Alazan. It may be interpreted as additional evidence for interracial crosses which were in the process of occurring and were producing heterosis for endosperm size. As a result of new heterozygous gene combinations, endosperm size increased, but was not matched by pericarp enlargement. The pericarp is a maternal tissue which would still be under control of the maternal genes and, therefore, adapted to the conservative endosperm size. Pressure applied on the pericarp by the enlarged endosperm would be responsible for such ruptures.

It appears that the Paracas maize, starting from the very early levels, is a composite of two popcorn races: Confite Iqueño, with small, round fasciated ears, irregular rowing, and predominantly brown or red pericarp color; and a Proto-Confite Morocho, with longer ears, distinct rowing, and with some proportion of cherry pericarp ears in the original populations. At more recent levels, mixed segregating populations may be recognized, and in them a few ears of some Anciently Derived races may be made out. Whether these are segregates of the original hybridization, or whether they appear as products of subsequent hybridization of additional races with the preceding hybrid populations, cannot be definitely stated at this time (Fig. 21).

On the basis of the study of pottery styles, Bennett (1948) established a cultural relationship between Wari, a main center of the Tiahuanaco cultural expression in the Department of Ayacucho in the highlands, and the Tiahuanaco Post-Classic Period on the South Coast. The similarity of pottery designs for the two regions has been stressed further by Strong (1957).

These contacts between the inhabitants of the inter-mountain high valleys of Ayacucho and the people of the coastal valleys of the Pisco, Ica, and Nazca regions were intensified at a rather late chronological period (Post Classic-Coastal Tiahuanaco).

The evidence for the presence of a proto form of Confite Morocho in the Early Paracas maize complex, however, (since this race is centrally distributed today in Ayacucho, and assuming that this region was also its original center of distribution) would point to earlier contact with the Sierra, starting at least at the lowest Paracas and Cerrillos levels. Reports of coca leaves being found at Paracas Cavernas (Towle, 1956) tend to confirm such early contacts.

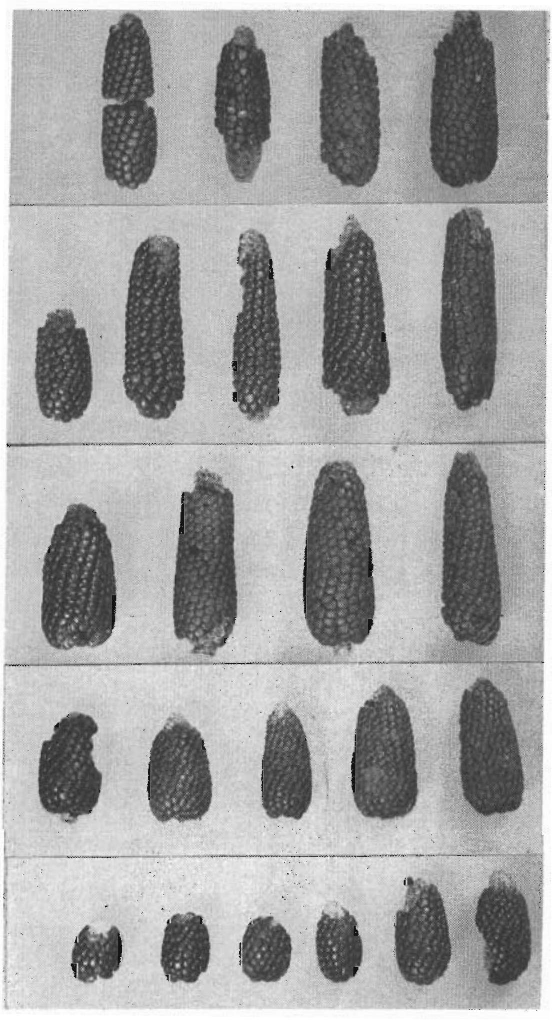


FIG. 21. General evolutionary series of maize from the Paracas Period (500 B.C.-250 A.D.) South Coast. Early Paracas maize (lower row) was chiefly Confite Iqueño. In the Late Paracas Period, Proto-Chaparreño, a race with influence from Proto-Chullpi became more abundant (ear at right, upper row). Collections at the Anthropological Museum, Lima.

3. *Ocucaje*

Two collections from Ocucaje Cavernas, a site contemporaneous with Paracas Cavernas, were studied. They proved to be similar in all characteristics to the Paracas Cavernas Confite Iqueño maize. The two collections had average ear lengths of 5.8 and 8.0 cm., respectively, average ear diameters of 2.65 and 2.95 cm., irregular rowing, no denting, no imbrication, alveolar cupules, spongy rachis texture, red pericarp color (some brown and some reddish brown), and a medium cob/rachis index averaging 1.75, based on a few cobs.

4. *Nazca*

The Nazca cultural period was approximately 1-800 A.D. Nineteen collections with a total of 193 ears of maize belonging to this period were studied and classified as to racial affinities.

The range of variability of the extreme average collection-measurements for several characters is indicated in the following: Ear length ranged from a low collection-average of 6.09 to a high of 10.10 cm.; ear diameter from 2.33 to 3.06 cm.; kernel length from 6.2 to 9.2 mm.; kernel width from 4.3 to 6.8 mm.; kernel thickness from 3.6 to 5.0 mm.; kernel distribution irregular, from the equivalent of approximately 10 rows minimum to a high collection average of 17.2; cob/rachis index averages were from 1.73 to 2.76.

The characteristics of the kernels were basically those of popcorn, with about 78 per cent of the ears either lacking or having slight imbrication, 11 per cent with moderate imbrication, seven per cent wth strong imbrication, and four per cent with very strong imbrication. Pericarp color frequencies were 60 per cent red or brown, 10 per cent reddish-brown, and 30 per cent cherry. About 5.5 per cent of the ears showed medium-strong denting, and 5 per cent exhibited very strong denting.

The husks varied in length between 11 and 16.5 cm., had an average of 14 veins per centimeter of width, with at least five or six husk leaves enclosing the ear. The diameter of the shank at the last node, proximal to the attachment of the cob, varied from 0.46 cm to 2.00 cm.

No clear-cut distinction is apparent between the maize of the Paracas and Nazca chronological levels. It seems that a somewhat higher degree of variability is present in the Nazca popu-

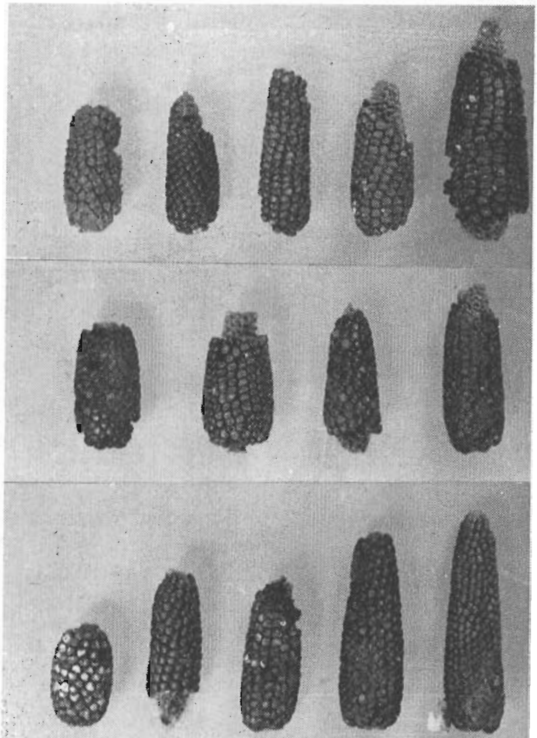


Fig. 22. Nazca Period corn (1-800 A.D.) South Coast. These collections probably overlap some Paracas Periods. A change from greater early prevalence of Confite Iqueño (lower rows) to predominance of floury- dented Proto-Chaparreño in later periods, is depicted in this series. An ear exhibiting characters of Proto-Pagaladroga is shown at the right of the third row. Collections at the Anthropological Museum, Lima.

lation, as the above data show, as, for example, the degree of imbrication and the frequency of pericarp-color phenotypes.

In a racial analysis of the general population, Confite Iqueño is the race with by far the highest frequency of phenotypic expression, followed by Proto-Confite Morocho. Certainly, at least in the early Nazca levels, mixtures of these two popcorns made up the bulk of the populations grown in the Ica-Nazca region. Some evolution in the direction of floury and semi-flint corn types is already noticeable, as evidenced by the fact that nearly 10 per cent of ears exhibit medium to strong denting. These ears have straight rows and larger kernels which diverge strongly from the nearly isodiametric condition or hexagonal-prismatic external shape of the kernels of Confite Iqueño, increasing their width much in proportion to their thickness. (Fig. 22).

One of the ears has a superficial resemblance to the race Tuxpeño from Mexico (see Wellhausen *et al,* 1952, p. 149)., with 16 rows of kernels, very hard glumes, but a high cob/rachis index. A Proto-Perla form and a Proto-Kculli form are also present in the prehistoric Nazca maize collections.

The Proto-Perla as well as the Confite Iqueño ears exhibit strong superficial kernel striations, probably produced by tight husk compression. This characteristic is present in most of the ears of these Nazca collections, and in the Paracas period corn.

A general survey of maize recovered from twelve archaeological locations in the Nazca area was made by Towle (1956). No precise information on racial characteristics is yet available, since the data obtained were meant to characterize the chronological epoch as a whole.

If we may generalize concerning the evolution observed in prehistoric maize on the South Coast we may point out that from the Early Paracas to the late Nazca Period there was a trend towards: (a) increase in ear length and diameter; (b) change in kernel arrangement from irregular to rowed; (c) increased induration in the cob tissues; (d) increased variability in several morphological traits; (e) appearance of new races and evidence of hybridization.

The Nazca and Paracas ear samples deposited at the Archaeological Museum of the University of San Marcos in Lima were obtained for the most part before modern stratigraphic methods were available. Although some collections are obviously very early and others late, the great majority cannot be accurately dated, and therefore give only a rough general idea of the evolutionary trends of maize over a long but indeterminate period of time. New archaeological maize collections from the same area will be needed for a more accurate picture of maize evolution on the South Coast.

NORTH COAST

A detailed study of maize recovered by Strong and Evans from excavations at several sites in the Viru Valley on the North Coast has been made by Towle (1952a). Some preliminary information is also available from a few ears of the Huaca Prieta excavations made by Junius Bird in the Chicama Valley, although the data on the bulk of the cobs of this collection are still unreported.

1. *Huaca Prieta*

The earliest corn material for Peru, accurately dated by radiocarbon activity, has been found at Huaca Prieta (Bennett and Bird, 1949). It is interesting to notice that maize does not appear with material of other cultivated species in the lowest, nonceramic Incipient Agriculture level, which goes as far back as 2500 B.C. In a neighboring site, however, which corresponds to the Guañape Period, also in the Epoch of Incipient Agriculture (Willey, 1953), small cobs of a very primitive type of corn appear for the first time. These cobs are characterized by an average length of 4.3 cm. (incomplete cobs); rachis diameter 6.3 mm.; cob diameter 12.3 mm.; cob/rachis index 2.13; and an average of 10 rows (Towle, 1952a).

The cobs were found associated with *Lagenaria siceraria* (Mol) Standl. (the common gourd), peanuts and beans, and also with the first pottery.

2. *Early Supe*

Forty-nine ears of maize excavated at the Aspero and Lighthouse sites near the town of Supe have been assigned to the Early Ancon-Early Supe Period of the Formative Epoch. They were found associated with cotton, peanuts, gourds, and miscellaneous plant materials.

The cobs varied somewhat in various quantitative characters, but as a whole the group was considered homogeneous and uniracial. It did not exhibit traits that could be considered more primitive than those of maize found in other locations along the Coast, although this was the earliest level isolated in this area (Towle, 1954).

Some statistics on this maize collection as given by Towle (1954), are: average cob length, 5.8 cm., varying from 3.0 to 10.6 cm.; average cob diameter, 19.2 mm.; cob/rachis index ranges from 1.4 to 2.2; average number of rows 13.2, and varying from eight to 18.

A certain broad similarity may be noted between the Supe maize and the South Coast maize of the same chronological period. Apparently it is the race Confite Iqueño which was grown at the same period in the Supe Valley, as well as in the South Coast valleys. In keeping with the generally lower row number of North Coast maize, the Supe maize exhibits a somewhat lower row number than its contemporaneous counterparts in the south.

3. *Tomaval.*

The cobs obtained at the Castillo de Tomaval site in the Viru Valley belong to the Gallinazo Period in the Late Formative to Classic Epoch; and although they have not been dated, we may place them in all probability between 300 B.C. and 300 A.D.

These cobs had a mean partial length of 5.2 cm. (they were incomplete), rachis diameter 9.3 cm., cob diameter 15.9 mm., cob/rachis index of 1.7, and average row number 12.6. The rachis tissue was classified as spongy in 10 per cent of the ears, and horny in 90 per cent (Towle, 1952a).

4. *Huaca de la Cruz*

At this site in the Viru Valley, which was assigned to a period between late Gallinazo and Early Mochica, approximately 500 A.D., the recovered maize material had the following characteristics: cob length 5.8 cm., (incomplete cob), rachis diameter 6.8 mm., cob diameter 13.1 mm., cob/rachis index 2.0, average row number 9.2; rachis tissue spongy in 29 per cent of the cobs, bony in 71 per cent; ear husk 15 to 18.5 cm. in length, tassels with nine to 10 branches (Towle, 1952a).

It is immediately evident from a comparison of the data shown above for each character that in the Viru Valley sequence very little change took place in the general morphology or the dimensions of the maize from the Guañape to Early Mochica Periods, paralleling the situation already described for the contemporaneous periods on the South Coast. A slight increase of several millimeters in the length and diameter of the cob represent the only definite changes occurring over a span of 1,000 to 1,500 years.

5. *Chimu*

Three ears found at Chan-Chan, the capital city of the Chimu Empire, in the Moche Valley were studied. They were placed in the Post-Classic Chimu Period, dated from 1000 to 1400 B.C., and are described below.

Two of the ears are typical of Proto-Alazan and had the following average measurements: ear length 10.7 cm., ear diameter 3.1 cm., kernel length 10.0 mm., kernel width 8.0 mm., 10 rows. The remaining ear had eight rows and might be considered as either Proto-Pardo or a Cuzcoid derivative. Its measurements were: ear length 11.0 mm., width of kernel 8.0 mm. All three ears had a strikingly low (8-10) row number as compared to the maize of approximately equal chronological levels on the South Coast.

The characteristic of average low row-number is recurrent in North Coast maize populations throughout all periods. From the early ten-rowed Huaca Prieta corn, through the Mochica populations in which 8-10 are the most frequent numbers, up to Chimu and Inca Levels, low row-number maize dominates. Such races as Alazan, Rienda, Pagaladroga, Huachano, Chancayano, and Pardo were derived from this low row-number complex.

From Supe southwards, increased average row-number is the rule from the Early Paracas through the Nazca Period, pointing to the higher frequency of the fasciated corn phenotypes in this area.

This situation suggests that the earliest corn brought down to the North Coast was an eight or 10 rowed popcorn, with slender ears, probably a Proto form of Confite Morocho. The original distribution of this race may be assumed by inference to have comprised the northern Sierra, including the Marañon valley.

The South Coast maize was influenced much more strongly in the initial agricultural periods by Confite Chavinense, which contributed its characteristic globular, fasciated ears, with irregular rows of isodiametric kernels to the early corn populations.

Confite Chavinense had probably been grown for a long time in the south central Andes before it appeared on the Coast as its derived race, Confite Iqueño.

CENTRAL COAST

No maize collections comparable to those found in the Early Formative Epoch on both the North and South Coasts have been described for the Central Coast.

1. *Ancon*

At Ancon a new stratigraphic sequence is being studied at the present time with material excavated in late 1959 by Mr. Duccio Bonavia of Lima. These studies are based on material from the early levels, parallel to Maranga and Playa Grande (Interlocking), up to the Tiahuanacoid intrusion.

A basic popcorn race with a relatively large cob-length/width ratio and cylindrical ears, Proto-Pagaladroga, was grown near Ancon, probably in the Chillon valley. At the Tiahuanaco level the continuous and consistent trend of increase in cob dimensions is abruptly stopped, and shorter-eared maize is introduced. The new ear-type found at this level exhibits in all its characteristics a definite similarity to the floury Chullpi-like maize from the La Molina site on the Central Coast, which is described later.

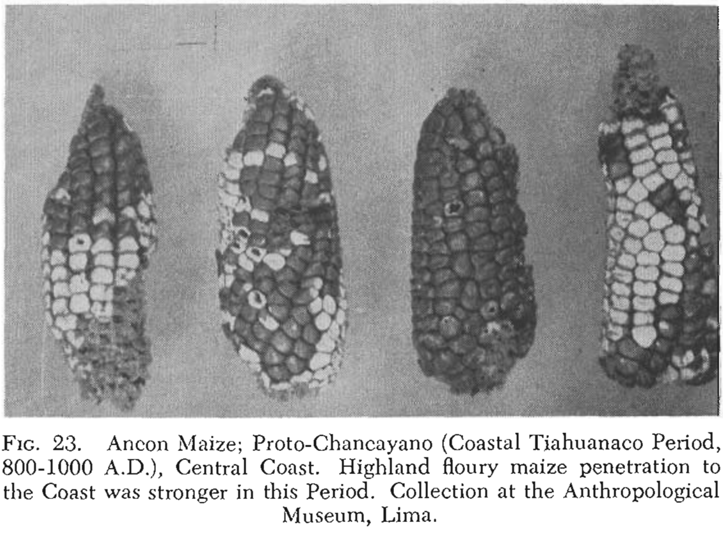


FIG. 23. Ancon Maize; Proto-Chancayano (Coastal Tiahuanaco Period, 800-1000 A.D.), Central Coast. Highland floury maize penetration to the Coast was stronger in this Period. Collection at the Anthropological Museum, Lima.

In still later periods, Late Ancon and Inca (Post-Classic), there is a definite increase in ear length, cob diameter, and size of kernels, thus approaching the characteristics of Proto-Chancayano (Fig. 23) from Ancon.

The following measurements and scores come from a single collection from Ancon, which were studied at the Archaeological Museum of the University of San Marcos in Lima, and which probably should be placed in the Post-Classic Era: average ear length 10.6 cm., average ear diameter 4.33 cm., average row number 14.4, with several ears exhibiting irregular kernel distribution, average kernel length 11.5 mm., kernel width 8.4 mm., and kernel thickness 5.0 mm., imbrication slight or none, intermediate denting; cupule wide and deep, very hairy; hardness of glumes intermediate.

2. *La Molina*

A large corn cache was found in a small underground silo at La Rinconada, Ate, in the Lima valley, near the Universidad Agraria grounds at La Molina. The ears were covered with sand

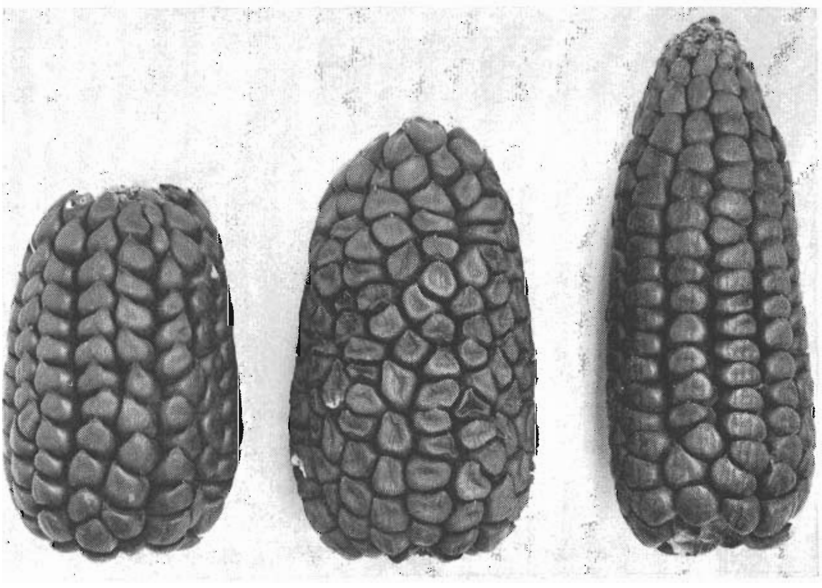


FIG. 24. La Molina archaeological maize showing the range of racial composition of its population. Ear at the right is Proto-Alazan; central ear is Proto-Chaparreño.

and were preserved in an exceptionally good condition. Although not accurately dated yet, this find is provisionally placed at around 800 A.D., within the Tiahuanacoid era of influence.

This maize represents the first archaeological collection positively dominated by Sierra Anciently Derived races. A large proportion of the ears of La Molina corn exhibit the gross external morphology of highland Chullpi: globular or spherical shape, irregular rowing, large kernels, and denting, such as appear today in the race Chaparreño. We call this race Proto-Chaparreño. In the same population straight-rowed ears occur very frequently which resemble Proto-Alazan of the North Coast or the modern race Perla, as well as intermediate type segregates between the extreme racial types. (Fig. 24).

The ears of La Molina maize were on the average 7.77 cm. long, 4.01 cm. wide; they had an average of 14.8 rows; the kernels measured on the average 10.4 mm. in length, 7.2 mm. in width, and 4.8 mm. in thickness; about 68 per cent of the ears had floury kernels, 16 per cent were flinty, and 16 per cent were dent; very strong imbrication was apparent in 12 per cent of the ears, intermediate in 16 per cent, slight in 16 per cent, and no imbrication in 56 per cent. The most frequent pericarp color was reddish brown, followed by red and then brown. No cherry-colored ears were found. The endosperm color in the kernels of ears of this collection, as is true of all prehistoric Peruvian maize yet encountered, is uniformly yellow, as opposed to the distinctly white endosperm of prehistoric Middle American maize.

The introduction of floury maize to the Peruvian Coast preceded the Tiahuanaco Period. It was a slow diffusive process into the original popcorn races, as is evidenced by the Paracas and Nazca archaeological material. The great predominance of floury maize in the Coastal Tiahuanaco Period following the era of slow diffusion was brought about by a sudden massive introduction of new maize from the highlands to the Coast, as the Ancon sequence and comparisons between other pre- and post-Tiahuanaco collections indicate.

Such a massive corn migration may have paralleled the transfer of highland populations to the coast by the Incas in order to settle loyal groups in newly conquered areas, *mitimaes* or *mitimaccunas* (Means, 1931). The advent of new uses for maize, such as in *chicha* and *mote*, which were likely to become prevalent with the appearance of a starchy endosperm maize, was probably marked at this time.

No actual ear specimen or other corn material from either the Sierra or the jungle regions was available for study. We shall, therefore, use information afforded by artistic representations in discussing the prehistoric highland races of corn in Peru.

MAIZE IN PRE-COLUMBIAN CERAMICS AND OTHER ART

Corn, one of the basic foods of the advanced pre-Columbian cultures of Peru, occurs in multiple forms of ceramic, stone, and metal artistic representations. These are particularly numerous in ceramics, where they appear in various forms. The forms include high relief moldings of ears applied on the surface of pots or vases, painted designs, stylized high-relief figures of ears or plants, anthropomorphized corn ears, and ear replicas, either stylized, molded, or built-up.

The stone and metal (gold or silver) replicas of ears or corn plants are often excessively stylized. In the case of stone they are carved; in metal replicas they are molded as solid figures (Fig. 25) or are made from gold foil, welded to give an ear-like appearance, hollow on the inside and usually excessively exaggerated in size.

Both the stone and the gold and silver replicas of corn ears probably served for ceremonial purposes, as will be discussed later.

MOLDED MAIZE CERAMICS

The molded ceramic representations of corn are of interest only when they are accurate copies in high-relief of actual specimens of ears which were grown at about the time of manufacture of the pot. In such cases definite ear measurements and other characteristics can be correlated with pottery styles, periods and horizons, and with cultural periods to which chronologies have been assigned from archaeological studies. Some of the actual negative molds used by the Mochicas and Chimus on the northern Peruvian coast have been found, and are exhibited at the Museum of the University of Trujillo, Peru. These molds were made of clay, which was applied in a plastic state to the actual ear specimen. They were then baked to hardness, and in turn, used repeatedly as negative molds on one to several pots. One or more of such molds were used on each vessel.

FIG. 25. Silver figurine from the Mochica Culture, ornamented with maize ears; maize plant with internodes in zig-zag arrangement, and topped by a "lorito," a bird which still is a pest to maize in many areas of Peru (*courtesy*, University of Trujillo, Peru).

Often a uniformly recurrent ear pattern is found on such pottery, so that care must be exercised when collecting measurements of such ear molds lest repetitive accumulation of the same data occur.

The particular usefulness of maize-ear moldings on clay comes undoubtedly from the perfect record which is left of the whole ear and kernel shape and their overall external configuration. This completes our picture of the prehistoric races, whenever shelled cobs are otherwise the only additional available material at a given site or period.

FIG. 26. Ears of a fasciated form of Proto-Confite Puntiagudo on a piece of pottery of the Mochica Culture. The ear to the left exhibits a very thick shank.

The northern coastal cultures have yielded the majority of the corn pottery; this consists principally of jars, either open-mouthed, anthropomorphized, or with stirrup spouts.

Clay and stone ear-replicas are particularly characteristic of the highlands (Cuzco and Ayacucho). An abundance of stylized stone ear-replicas (some rather accurate) have been found on the Central Coast, especially in the Chancay culture. Painted vases showing stylized corn plants have been obtained on the North and South Coasts and from the Cuzco area.

A rather extensive search was made for corn pottery in several museums and private collections in Peru. Many of the pottery types illustrated here reappeared very often, as if they had been mass-produced, and had recurring artistic or ceremonial designs. Therefore no attempt has been made to describe all the available material, which would have burdened too much the present discussion, but only the extreme types and the range in the abundant types that might yield some information on the nature of the corn.

The North Coast ceramic tradition, starting with the Coastal Chavin or Cupisnique style and progressing through the Salinar, Gallinazo, Mochica, and Chimu Periods and styles, is one of modeling, sculpturing, and mold technics (Willey, 1949). This pottery continuity is helpful in the typological interpretation of the corn-ear representations, most of which come from the North Coast area.

RACES OF MAIZE IN THE MOCHICA PERIOD

The Mochica Pottery horizon yields the following molded materials, which have been classified and grouped into the races described below.

Race I. Fasciated Proto-Confite Puntiagudo (Fig. 26). Ear length 5.8 cm.; ear width 3.8 cm.; ovoid shaped; irregular kernel arrangement; small beaked kernels, strongly imbricated. Only one ceramic specimen showing this racial type from the Coast is available. It is deposited in Mr. Larco Hoyle's collection, previously at Chiclin, now at Lima, Peru.

Since no further evidence of the presence of this race has been found in the Coastal region, we may be safe in assuming that this particular pottery specimen was made by copying ears brought down from the northern Highlands, where Confite Puntiagudo was undoubtedly present at the time. Fasciated ears of

Confite Puntiagudo are not infrequently found today in fields where this race is grown (see Fig. 80). It might at one time have been abundant in its fasciated form over all the Sierra region, as is apparent from the multiplicity of representations in the southern Highlands (for example, see Fig. 40).

One interesting feature of this ceramic replica of Confite Puntiagudo is its very thick shank. This feature is present today in Confite Puntiagudo and Enano, differentiating the former race from other highland races to an outstanding degree in respect to this characteristic.

The considerable increase in vascularization and the accompanying induration of the cob may be an indication of Tripsacum introgression and of simple mutation to cob fasciation. This latter mechanism probably achieved the original increase in cob diameter, yielding a primary form of fasciated popcorn, still differentiated in some modern collections of Confite Puntiagudo, and also present in other primitive fasciated popcorns, such as Confite Iqueño. A secondary increase, this time in shank diameter, may have been brought about by hybridization with tripsacoid corn (Enano or Piricinco), probably in the Madre de Dios and Beni river basins of Peru and Bolivia (see p. 164).

At any rate in the Mochica Period, chronologically between 500 A.D. and 800 A.D., we may be certain that parallel to the Coastal races described above there existed a fasciated form of Confite Puntiagudo, which could have given rise earlier or contemporaneously to other races (i.e. Paro, p. 183), and which at that time probably had already undergone some Tripsacum introgression.

Race II. Proto-Pagaladroga (Fig. 27). Similar to present day Pagaladroga. Ear length 7.7 to 11.5 cm., average 9.7 cm., average width 3.0 cm., average number of rows 14, often tending to a spiral, irregular, or tesselate kernel arrangement; average number of kernels per row 24; average width of kernel 4.75 mm., average thickness of kernel 4 mm., kernel imbrication intermediate to strong.

Race III. Proto-Mochero (Fig. 28). Similar to present-day Mochero. Ear length 2.8 to 5.0 cm., average length 4.1 cm., width 2.1 cm., row number 10, mostly in an irregular arrangement, 6 to 12 kernels per row, kernel width average 6.25 mm., kernel thickness average 4.75 mm., imbrication none to slight.

FIG. 27. Molded ears of Proto-Pagaladroga on Mochica pottery show their characteristic cylindrical shape and the spiral arrangement and the imbrication (upward pointedness) of the kernels (⅔ natural size).

This race is well differentiated from Races II and IV not only by the overall kernel and ear dimensions, but also by the extremely irregular arrangement of its kernels on the ear and by the very slight degree of imbrication.

Race IV. Proto-Alazan (Fig. 29, 30). Similar to present day

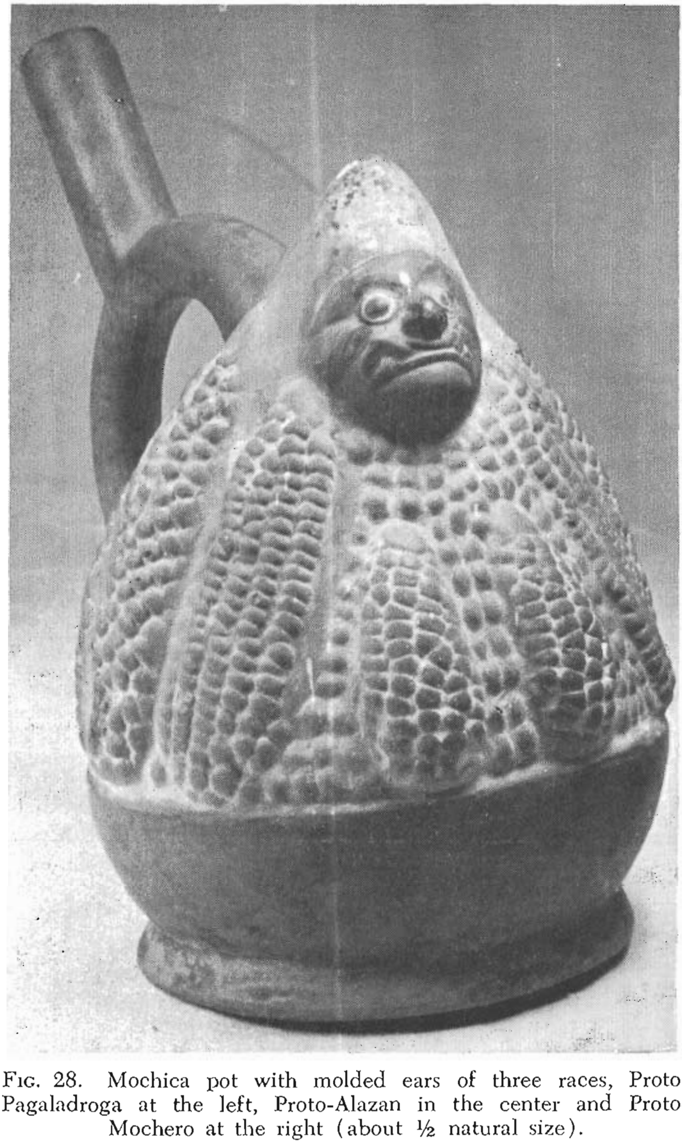


FIG. 28. Mochica pot with molded ears of three races, Proto-Pagaladroga at the left, Proto-Alazan in the center and Proto-Mochero at the right (about ½ natural size).

Alazan. Ear length 8.0 to 8.5 cm., ear diameter 2.3 to 3.4 cm., number of rows 10, which are straight, sometimes reaching 14 and spiraling; 20 to 22 kernels per row, kernel width 5 to 6 mm., thickness 3.5 to 4 mm., imbrication slight to intermediate.

Race V. Proto-Rabo de Zorro. Average ear length 10.2 cm.

FIG. 29. Molded ears in the center of this Mochica pot correspond to a segregation series. Proto-Alazan is approached by the ear at the left; the remaining three ears show influence of Proto-Pagaladroga. The small ears both in the upper and lower part are Proto-Mochero.

with a range of 8.5 to 12.3 cm., mid-ear width 1.8 cm., width at base of ear 2.4 cm., making a sizable and characteristic ear butt; uniformly eight rows of kernels, average of 24.5 kernels per row; average kernel width seven mm., average kernel thickness 4.4 mm., imbrication slight to strong, with most pottery specimens

FIG. 30. Molded ears of Proto-Alazan on a pottery vessel of the Mochica Period. Note the straight rows of kernels (⅖ natural size).

varying from intermediate to strong.

The ears of this race are the longest of any found on molded Peruvian pottery, and correspond well with the relative length, overall appearance, shape, and dimensions of ears and kernels of the modern race Rabo de Zorro.

The molded specimens convey the impression of ears with a great deal of flexibility, and the pottery-makers may have been exaggerating this feature by drawing the tips of the ear around and over the heads of the main deity motifs (Fig. 31).

FIG. 31. Proto-Rabo de Zorro ears molded on a Mochica maize deity ceramic vessel. Note the long ears with eight rows, separated by deep furrows, imbrication of the kernels, and spreading habit of members of spikelet pairs.

FIG. 32. Piricinco-like ears of Proto-Rabo de Zorro molded on a Mochica ceramic vessel (½ natural size). Courtesy, Archaeological Collections of Museo Larco Herrera.

The specimen shown in Fig. 32 and in Fig. 33 (which is an enlargement of the previous one) has prominent ear butts such as are found in the race Piricinco today. We are postulating that

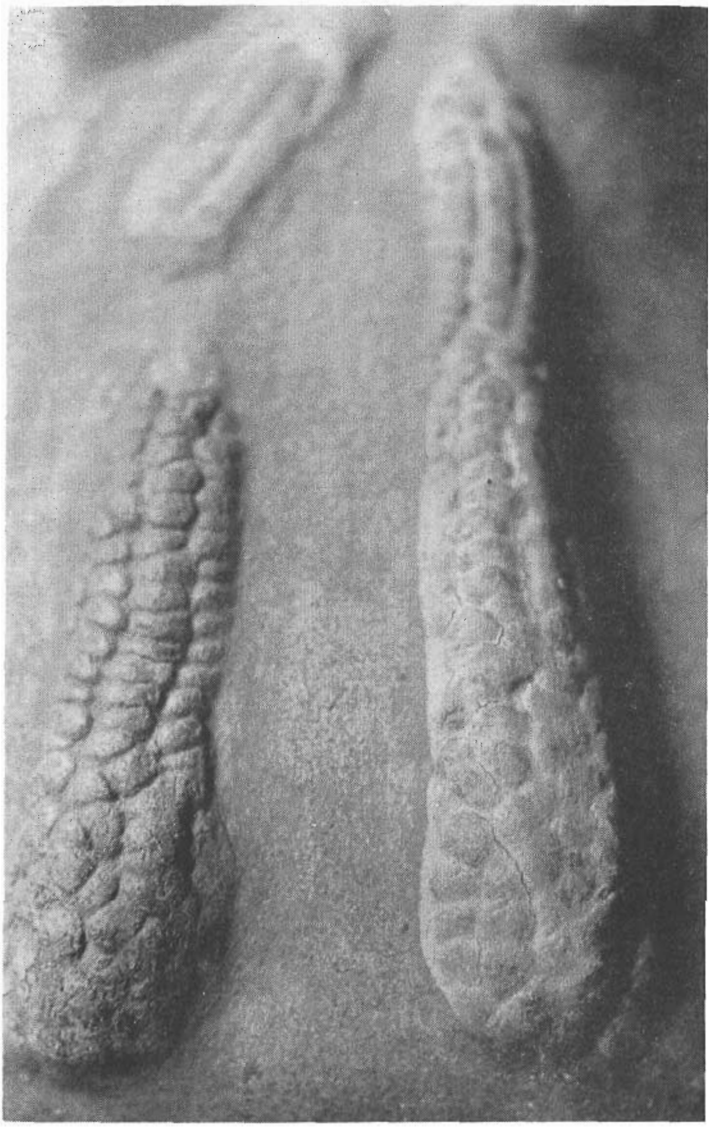


FIG. 33. Details of Piricincoid ears of Proto-Rabo de Zorro, from Mochica vessel shown in Fig. 32. Note the prominent butts and the long, slender ears with 8 rows of kernels (slightly larger than natural size).

Piricinco originated as a hybrid between Rabo de Zorro and Enano, and certainly the molded ears in the described ceramic specimen appear to be intermediate between these two races.

FIG. 34. Ear of Proto-Kculli on a *chicha* vessel of the Mochica Period, showing the characteristic rounded and clustered kernels of this race (½ natural size).

They probably represent ears which were grown at medium altitudes in one of the northern subtropical inter-mountain valleys, and were brought down to the Coast, where they would have been likely to attract a pot-maker's attention because of their unusual length and shape. This race might also have been grown

FIG. 35. Proto-Ancashino molded ears on a Mochica vessel.

in limited areas of the northern Coast of Peru.

The molded replicas shown in Fig. 31 could well have been representations of precursors of the coastal race Rienda, a modern

FIG. 36. Molded ears on a Mochica ceramic vessel of a Cuzcoid derivative, similar to present day Chancayano.

extreme variant of which (Fig. 180) matches very well its prehistoric molded ancestral representations.

Race VI. Proto-Kculli. Similar to present day Kculli. Ear length short, average 4.0 cm., ear width 1.9 cm., irregular kernel arrangement equivalent to 10-12 rows, and resembling a bunch of grapes, with about 10 kernels diagonally arranged from base to tip of ear; kernels round.

In Fig. 34 a good molded specimen of Proto-Kculli is shown on a utilitarian rather than decorative type of pottery container, used probably for making *chicha*. The association of Kculli with the making of *chicha* evidently starts at least as far back as the Mochica or North Coast Classic Period and extends up to our times.

Race VII. Proto-Chancayano (Fig. 36). Similar to the present day race Chancayano. One specimen. Ear length 6.5 cm., diameter 2.3 cm., 10 rows of kernels, with 18 kernels per row, kernel width 7 mm., thickness 3 mm., slightly imbricated.

The ear is characteristically cigar shaped, with a smooth rounding at the base, deep furrows between rows and a general resemblance to modern Chancayano, or extreme variant of an ear of Pardo. It would be difficult to establish on the basis of a single specimen whether the race Chancayano had already been differentiated or was in the process of differentiating at this time, or whether segregating Proto-Pardo populations only were present, in which case undoubtedly ears with a row number above eight would be quite frequent.

Race VIII. Proto-Ancashino (Fig. 35). Similar to present day Ancashino. One specimen. Ear length 9.3 cm., ear diameter 3.2 cm., shape conical with a strong taper towards the tip and a medium, smooth tapering at the base; 14 to 16 rows of kernels, with 19 kernels per row; kernel width six mm., kernel thickness four mm., fabrication none to slight.

Ancashino is a highland race with red or brown pericarp color. The presence of characteristic conic Ancashino ears on the coast in the Mochica chronological level is interesting, since the race Alazan, now the prevailing native race on the North Coast, is characterized by its deep red pericarp color and slight kernel imbrication and a number of general morphological ear features which resemble those of Ancashino.

RACES OF MAIZE IN THE CHIMU PERIOD

The Chimu pottery horizon differs from the Mochica in its predominantly black pottery obtained by kiln burning with restricted air admission, and in its poorer artistic quality. (Willey, 1949, Kroeber, 1949).

The phytomorphic pottery of the Chimus is less frequent than that of the Mochicas in its representation of maize as molded ears, but has a recurrent pattern of a divinity personage often holding corn and cassava plants. This divinity personage and the "warrior-priest" entity postulated by Strong and Evans (1952) seem to have a common underlying basis.

Yacovleff and Herrera (1934) call this figure vegetable carrier *portador de vegetales* (ekeko), and illustrate several from Nazca and Paracas textiles and from Mochica ceramics and silver figures. Except for a Nazca funeral cloth which shows the vegetable carrier occasionally without maize, all other designs of this divinity have corn as one of the plants. Arriaga, cited by Yacovleff and Herrera (1934), refers to the maize borne by these vegetable carriers as *zaramamas* or *saramamas* (Quechua for "mother of corn").

A point of interest brought up by the Chimu divinity representations is the simultaneous appearance of corn and cassava designs on vases. These are found very often in this cultural horizon, thus indicating the parallel importance of both crop plants in the northern coastal region, and pointing furthermore to the likelihood that maize and cassava were being grown in association in prehistoric times. They are still grown together today in the Tumbes and Zarumilla river valleys on the coast near the border of Ecuador. Before Pima cotton began to be cultivated on a large commercial scale in northern Peru, in the latter part of the last century, the growing of corn and cassava, in association, was practiced from the Department of Piura south to the Motupe Valley.

The following corn races, molded on ceramic vessels, have been recognized in the Chimu Period. They are given the same designations as their counterparts in the Mochica horizon:

Race IX. Proto-Confite Morocho. It might appear that, toward the end of the Chimu Period, Inca highland influence in the form of plant introduction was becoming more pronounced.

The Inca horizon, which on the North Coast starts at about 1470 A.D., has provided a single black ceramic vase of typical Inca design (Fig. 38). One ear has been molded four times on this vase, and may be described as follows.

Similar to present-day Confite Morocho. Ear length 7.3 cm.; diameter 1.9 cm.; eight rows with 17 kernels per row, kernel width six mm.; kernel thickness four mm.; imbrication intermediate.

Although this molded specimen resembles closely the present-day race Confite Morocho, it is obviously an extreme variant of it. It might well have been an evolved form of Confite Morocho, different from the precursors of Huancavelicano, or even the eight-rowed popcorn Kcarapampa race of Bolivia.

FIG. 37. Maize deity representation on black pottery of the Chimu Culture with ears of Proto-Cuzco.

Race VI. Proto-Kculli. Similar to present-day Kculli. Ear length 4.3 cm.; ear diameter 2.0 cm.; irregular kernel distribution on ear, approaching 10 to 12 rows and spiral-like; imbrication medium to strong.

Race VIII. Proto-Ancashino. Similar to present day Ancashino. One specimen. The ear measurements of this race are given below for the purpose of comparison with the same race at the Mochica level (Fig. 35). Ear length 8.6 cm.; ear diameter

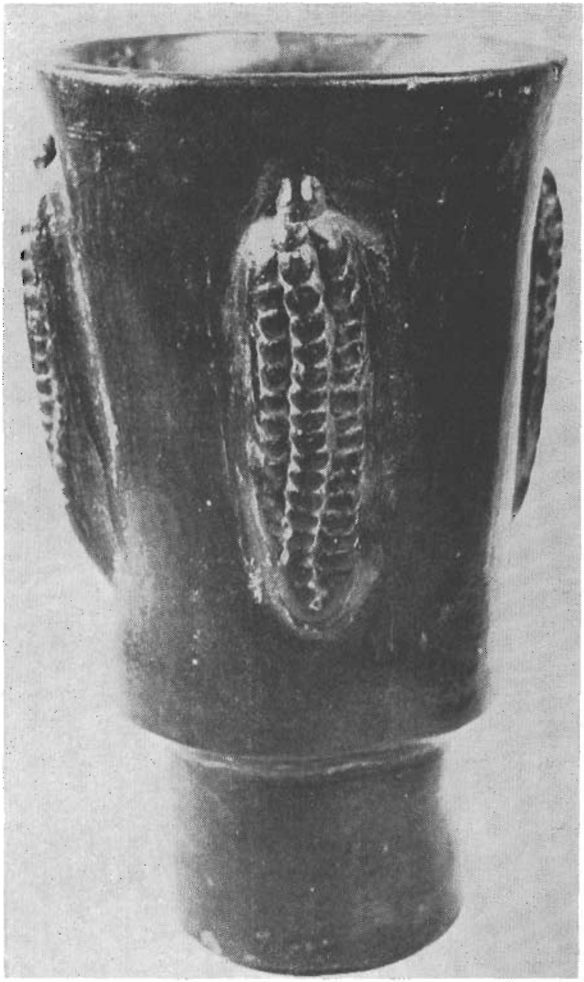


FIG. 38. Molded ears of a popcorn, presumably Proto-Confite Morocho or Proto-Karapampa on a black ceramic vessel of the Coastal Inca Period (courtesy University of Trujillo, Peru).

3.4 cm.; 12 rows with 21 kernels per row, kernel width seven mm.; kernel thickness seven mm.; imbrication slight.

Race V. Proto-Rabo de Zorro. Cylindrical ears, length 5.1 cm.; diameter 1.6 cm.; eight rows of kernels, with 16 kernels per row, imbrication slight.

Race X. Proto-Cuzco. (Fig. 37) Similar to the present day Cuzco. One pottery specimen, three ears, cigar shaped, length 9.4 cm.; diameter 2.4 cm.; eight rows with 21 kernels per row; kernel width six mm.; thickness three mm.; imbrication none to slight.

This race resembles Cuzco corn in that the eight-rowed ears are tapering at both ends to a larger degree than in Pardo, and have a more globose shape than the latter race. On the other hand, there is a possibility that the single globular-shaped Cuzco type ear on the black Chimu vessel shown in Fig. 37 is only a variant of Pardo corn. The definite resemblance of the two additional ears carried by the human figure on the same ceramic pot to Pardo is in favor of this last interpretation.

STONE AND CERAMIC EAR REPLICAS

The abundance of stone replicas of corn is evidence of the widespread utilitarian or religious use to which these objects were put. Arriaga, cited by Yacovleff and Herrera (1934), gives an early account of the existence of these stone replicas, which he also refers to as *saramamas:* ". . . otras mazorcas son de piedra labrada como Choclo o mazorcas de maiz con sus granos relevados, y de estas suelen tener muchas en lugar de conopas."

According to Cobo (1653, XIII, 7), the *saramamas* could be thought of as "good luck charms to bring about the helpful action of a mother of maize" deity.

Both stone and ceramic replicas of maize ears have been found in the highlands. The largest collection is now at the Archaeological Museum of the University of Cuzco. Some of the ceramic replicas there are extremely accurate in detail, and show an interesting and unique conception of ceramic construction. A central clay cob was first made, and on this the kernels were inserted singly, imitating a perfect ear arrangement, to the point of showing such details as pairing of spikelets, kernel alternation with tesselate patterns, and even imbrication detail. The whole ear was then fired. No wonder that Knowlton reported, in 1919, an ear of corn of this type which was purchased by Mr. W. F. Parks from a dealer in curios in Cuzco, as being "fossilized" and constituting a new species, *Zea antiqua.* Knowlton stated: "It seems hardly likely to be younger than at least several thousands of years," and ". . . it falls very little short of supplying the needed paleontological data on the antiquity of maize."

Collins (1919), after reviewing Knowlton's information, compared the "fossil" ear with photographs of ears that can be recognized today as belonging to the races Confite Puntiagudo, Huayleño, Confite Puneño, and Huancavelicano. He concluded that while it was not duplicated by any ear in his collection, it did not present any new characters, but rather a recombination of characters of existing types. Brown (1934), finally showed the artifact nature of the ear by sectioning it.

The races that may be recognized in these ceramic replicas are the following: Proto-Chullpi (Fig. 39), Proto-Kculli (Fig. 40), Proto-Huancavelicano, branched (Fig. 41), Proto-Huayleño (Fig. 40), Proto-Alazan, and Confite Chavinense, a postulated ancestral popcorn race indigenous to the Peruvian Andes which approaches Confite Iqueño in ear appearance (Fig. 41). In Mangelsdorf and Reeves (1939), the center and right photographs in Fig. 15 are of clay ear replicas of Confite Chavinense. The left ear replica appears to be a representation of Proto-Kculli.

Collins (1919), Figs. 1, 2, and 3, gives three views of a ceramic

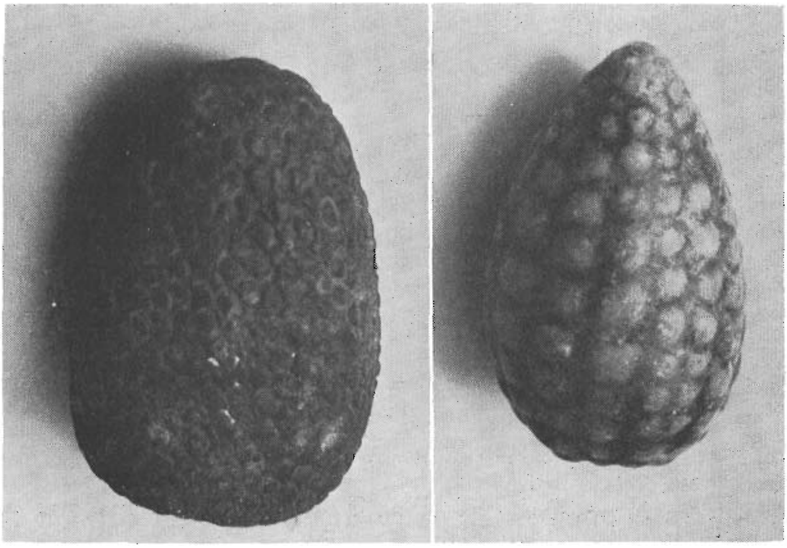


FIG. 39. Ceramic ear replica of Proto-Chullpi. At Archaeological Museum, University of Cuzco, Peru. Natural size. (Photograph, courtesy Dr. Cesar Vargas)

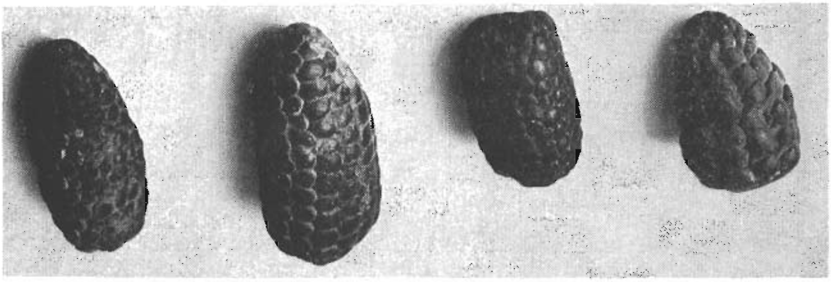


FIG. 40. Ceramic ear replicas from the highlands of Peru. Ear at right represents a popcorn probably a fasciated Confite Puntiagudo; middle ears are presumably Proto-Huayleño; ear at left is Proto-Kculli. At Archaeological Museum, University of Cuzco, Peru. One-half natural size. (Photograph, courtesy Dr. Cesar Vargas).

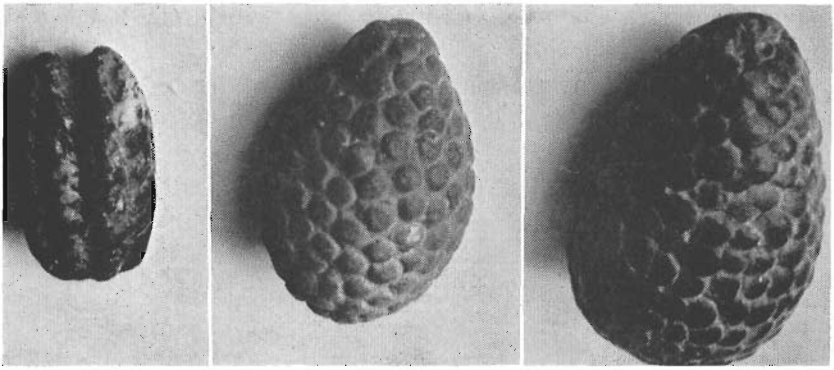


FIG. 41. Ear replicas. At left, stone replica of branched ear of Huancavelicano; middle and right, ceramic replicas of derived forms of Confite Chavinense. At Archaeological Museum, University of Cuzco, Peru. Natural size. (Photograph, courtesy Dr. Cesar Vargas).

representation of a fasciated form of Proto-Confite Puntiagudo or what could also have been an imbricated form of Confite Chavinense.

Short descriptions of the ear replicas at the University of Cuzco Archaeological Museum with the race represented by each follow:

Proto-Chullpi. (Specimen U-1383). Ear length 6.0 cm.; maximum width 4.1 cm.; irregular row arrangement. Stylized.

Confite Chavinense. Three specimens: Specimen U-1382. Ear length 4.4 cm.; width 2.9 cm.; ovoid ear shape, 18 rows; tesselate kernel arrangement, imbrication intermediate. Specimen

U-1389. Ear length 5.0 cm.; maximum width 3.4 cm.; ovoid shape, 20 rows, no imbrication. Specimen U-1391. Ear length 5.8 cm.; width 2.8 cm.; ovoid-elliptical; tapering at both base and tip; 18 rows; slight imbrication.

Proto-Alazan (Specimen U-1385). Ear length 6.5 cm.; width 3.2 cm.; shape cylindrical, 14 rows, straight and interlocked, no imbrication.

Proto-Huayleño or Fasciated Confite Chavinense. (Specimen U-1388) Ear length 4.7 cm.; maximum width 2.9 cm.; fasciated form of Confite Chavinense, 18 rows, tending to straight rowing.

Proto-Kculli (Specimen U-1384). Ear length 4.9 cm.; maximum width 3.2 cm.; shape conical, 10 rows of large, pointed, strongly imbricated kernels.

Proto Huancavelicano. (Specimen U-1387). Ear length 3.2 cm.; maximum width 2.0 cm.; branched ear (twins), eight rows of imbricated kernels each.

This stylized ear is representative of an imbricated corn race, which could well be a modified form of Confite Morocho. It compares well with actual modern ears such as those in Fig. 48 left; see also Fig. 38 of an Inca-type vase from the North Coast.

Proto-Huayleño. (Specimen U-1390). Stylized ear with 15 rows.

MAIZE IN ARTISTIC METAL WORK

The representations of corn in artistic metal work are scarce. A few large hollow ears, hammered or mold-pressed on gold foil, and then welded to give them a cylindrical shape, are in the private collection of Mr. Hugo Cohen of Lima, Peru. These ears are about 20 cm. long, larger than any known prehistoric corn in Peru, and have many (14-16) rows of kernels. If indeed they are of pre-Columbian manufacture, they surely are idealized and perhaps intended for ceremonial purposes.

A metal-worked corn representation has been found on the northern Peruvian Coast in the Chimu city of Chan-Chan (Fig. 25). It shows a silver idol, about eight cm. tall, formed by a human figure bearing a head dress of corn ears, while more ears, also ovoid-elliptical in shape, protrude from his limbs, and a highly zig-zag stalked maize plant, crowned by a *lorito* (parrot), stands behind him.

It is, incidentally, interesting to note the repeated association of *lorito* birds with corn in both Nazca and North Coast art. Today, in many subtropical areas of Peru, *loritos* still constitute one of the worst plagues of corn.

It may well be that the development of husks extending beyond the ear tips, as found in Peruvian archaeological corn, was in part the result of a protective structure against this plague, as well as against insect attack (Fig. 42).

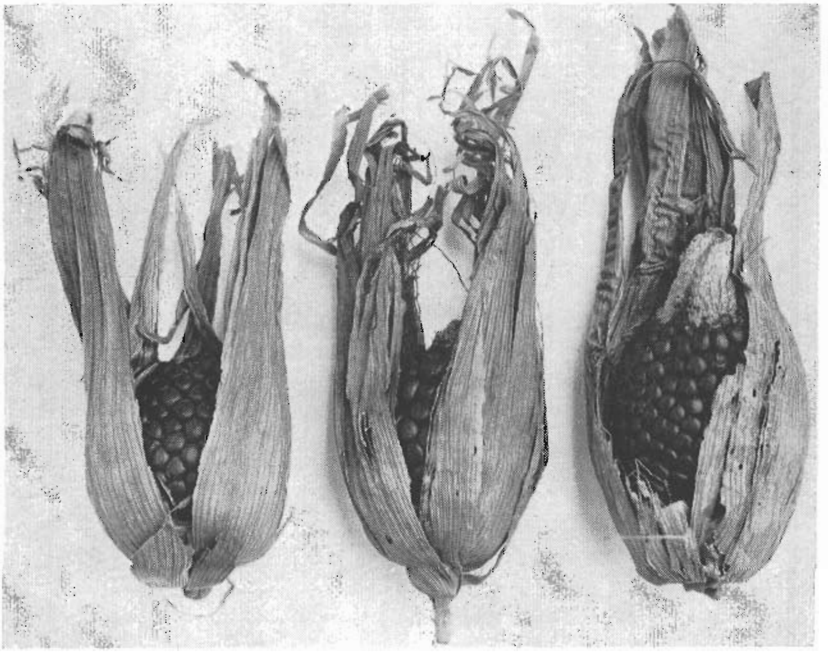


FIG. 42. Archaeological ears of Confite Iqueño from Los Cerrillos, Ica, showing the large extension of the husks beyond the ear tip, providing good ear cover and protection against insect attack. Three-fourths natural size.

THE CHRONOLOGY OF PREHISTORIC MAIZE EVOLUTION IN PERU

We shall now propose a tentative chronology based on archaeological and historical information for the first appearance of all Peruvian races which originated in prehistoric times.

Although we cannot definitely state at this time when and where corn cultivation began in Peru, we may hypothesize that

TABLE 7. Time and Area of First Appearance of Some *Prehistoric Corn Races in Peru.*

		Coast				
Date	*Epoch and Period*	*North*	*Central*	*South*	*Sierra*	*Selva*
1500 A.D.						
	V. Post Classic	Alazan	Proto-Pardo		Cuzco	
			Proto-Chancayano			
		Proto-Rienda				
800 A.D.						
	IV. Classic	Proto-Alazan			Proto-Huayleño	
		Proto-Perla		Proto-Chaparreño		
		Proto-Pagaladroga	Proto-Chaparreño		Proto-Huancavelicano	
		Proto-Rabo de Zorro		Proto-Pagaladroga		
		Proto-Pardo				
		Proto-Mochero			Proto-Ancashino	Piricinco
B.C./A.D.						

TABLE 7. Time and Area of First Appearance of Some *Prehistoric Corn Races in Peru* (Continued).

		Coast				
Date	*Epoch and Period*	*North*	*Central*	*South*	*Sierra*	*Selva*
B.C./A.D.						
	III. Formative	Confite Iqueño Proto-Confite Morocho	Confite Iqueño Proto-Confite Morocho	Confite Iqueño Proto-Confite Morocho	Kculli Proto-Rabo de Zorro Uchuquilla Confite Puneño Proto-Chullpi Confite Puntiagudo	Enano
1000 B.C.						
	II. Incipient Agriculture				Proto-Kculli Confite Chavinense Proto-Confite Morocho	
2500 B.C.						
	I. Pre-agricultural				Wild Maize Races	

it started in the Incipient Agriculture Epoch, at least before 1000 B.C. at the middle altitudes of the Sierra. Highland popcorn races appeared on the Coast in the Formative Epoch; the first hybrid populations for which we have evidence were present on the South Coast by about 500 B.C. At least eight races were in existence in Peru by the end of the Formative Epoch (beginning of the first century, A.D.). By the end of the Classic Epoch (1000 A.D.) some ten new races had been added. During the next 500 years of the Post-Classic Epoch at least four additional races were formed.

Our estimate of the number of races appearing during each of the main Epochs into which Peruvian cultural chronology is divided, may err by being too low, since it is based solely on the archaeological evidence available at this time. It will undoubtedly change as additional relevant archaeological information becomes available.

Table 7 presents this tentative chronology of the first appearance of races known to have originated in prehistoric times. Peruvian maize races not shown in the table are probably of a more recent origin and appeared during the Spanish Colonial or Republican periods.

CHARACTERS USED IN THE CLASSIFICATION OF EXISTING RACES

For the sake of consistency of presentation and ease of cross-reference, the characters and methods utilized for the description and differentiation of the maize races in Peru were selected to conform, in general, to those used in previous studies of this series. Although Wellhausen *et al* (1952) and Roberts *et al* (1957) have, in particular, given a detailed account of the methods of quantitative analysis of the various discriminating characters used in their studies, and which we are largely following, we are repeating their descriptions here for the convenience of those readers who may not have their publications at hand.

Some morphological characters were also studied following methods suggested by Nickerson (1953), while others were analyzed using original methods, described here for the first time. Cytological analyses more detailed than those made in former publications in this series, and pericarp and cob-color phenotype-frequency studies have also been incorporated in this monograph. Their usefulness has been proven, beyond doubt, in the classification of the races of maize in Peru.

Whenever possible ten ears of each of the original collection were used for the study of the various characters. A composite random shelled-seed sample of all the ears of each collection was then selected for a one or two-row planting at either one or more locations, with maximums of 52 or 104 plants per plot. The allocation of collections to different planting locations was based on the elevation of the original habitat of each collection. Thus, collections originating below 2,000 meters were planted at the coastal stations (La Molina and Paramonga); those originating at elevations between 2,000 and 2,800 meters were planted preferably in the Urubamba valley at 2,800 meters, while those originating at higher elevations were grown at the Mantaro (Department of Junin) Station and at Kcaira (Department of Cuzco), both at 3,200 meters above sea level (Table 1).

Additional data on ear characters and the first information on plant and tassel characters were collected at all the locations using ten individual measurements per collection for each character. No attempt was made to obtain weighted estimates of the mean values of the characters, corrected for location or year. The large number of such individual character measurements (running in the order of tens of thousands) would have made this task impossible. For the purpose of taxonomic differentiation, however, the order of magnitude of the differences between mean racial values for most of the characters was sufficient for an accurate characterization of each race.

The final morphological data, as well as material for cytological examination, were collected at La Molina, Cuzco, and Huanta, Ayacucho (2,300 meters above sea level).

The original data, together with photographs of the ears of each collection were filed in a Kardex-type system, where they were accessible for easy reference and survey. Samples made up of three ears of the original collections were maintained as museum specimens.

A first approach to racial classification was made on the basis of grouping ears with similar morphological characteristics originating in analogous elevation zones. This classification was generally supported or was altered in some cases by the plant and tassel data. Dubious groups were also identified and given a provisional nomenclature, pending further study.

Typical collections from each race breeding true to type were then grown for additional data and for visual comparisons. At this stage, some of the entries on the dubious group were elevated to the rank of bona fide races, while others were dropped. All measurements finally regarded as typical of a given race were then averaged to give the racial mean values listed in Tables 2A to 6A and 8A to 11A.

The final screening of the races was made at the time of preparation of the manuscript of the present publication, when cytological, morphological, geographical, and archaeological information were used jointly.

This multi-factorial approach to racial classification has the definite advantage of giving a wide basis of judgment for defining the races and establishing their relationships. It minimizes the error that might be associated with single-character or few-character discriminants as the basis for building up the systematics of maize races.

VEGETATIVE PLANT CHARACTERS

Range of adaptation to altitude. Altitude is the main factor conditioning the geographic distribution of maize races in Peru. It affects the environment in which corn grows in many ways: through temperature effects, length of frost-free period, intensity and quality of light, precipitation, soil type and fertility, etc.

The altitude of the site of each original collection was obtained by means of aneroid altimeters, compensated for known elevation "bench marks" at the time of collecting. In some cases altitudes were determined to the nearest 50 meters by interpolation of the locality of collection in the contour lines of detailed charts of the Peruvian Military Geographical Institute.

Maturity. Comparative maturity measurements are given as the number of days from planting to the time when half of the plants in a plot of each collection at a given locality had silked. It was averaged for all typical collections.

Height of Plant. This is based on average measurements for ten plants from ground level to base of tassel for each typical collection.

Height of Ear. This measurement was taken from ground level to the vertex of the angle of insertion of the uppermost developed ear on the stalk.

Total Number of Leaves and Leaves Above the Ear. Racial means were obtained by averaging direct counts on typical collections. Nodes were checked to avoid by-passing broken leaves. The uppermost developed ear was the reference for the second set of data. Leaf rosettes at the last node, whenever present, were counted as a single leaf.

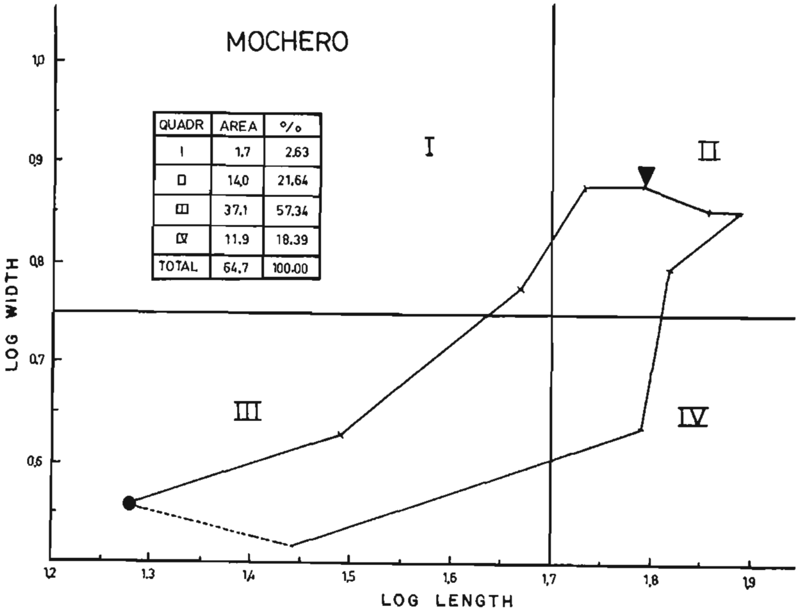
Length and Width of Leaf. The leaf blade arising from the node of ear insertion was measured for length from ligule to tip; width was the maximum for the same leaf.

Leaf Area. Only plants having the modal number of leaves per collection and race were measured for this character. Leaf area was obtained by Montgomery's (1911) method of adding the products of $3/4$ x length x width for each leaf, which was found to give an estimation bias of only 1.89 per cent of the true area (Grobman, 1953). In very few instances, a less accurate method based on multiple regression relations between the ear-leaf dimensions and total number of leaves had to be used, giving an estimation bias of less than 10 per cent (Grobman, *ibid.*).

Venation Index. This is the ratio between number of veins and maximum width of leaf. Venation indices are of higher value in primitive races and tend to decrease with increase in the relative degree of evolution of each race.

Leaf Pattern Indices and Diagram. The diagram was obtained by plotting the logarithm of length against the logarithm of width for each leaf, on an X-Y coordinate system, for plants belonging to the modal leaf-number class. A polygon was then drawn, uniting the plotted points in succession. End points were closed with a straight line. Two conventional axes, one vertical to 1.7 on the X and the other to 0.75 on the Y, divide the area enclosed by the polygon uniting the points into sub-areas within each quadrant, whose percentage area values are recorded in Table 3A. Relative values indicate relationships between pattern of length/width relative development (Grobman, 1958b), as well as divergence between leaf length/width ratios of first and last leaf. Fig. 43 gives an example of how the diagram and indices were obtained.

A large percentage value in Quadrant I means that the pattern of leaf growth is such as to produce short and narrow leaves;



QUADR	AREA	%
I	1,7	2,63
II	14,0	21,64
III	37,1	57.34
IV	11,9	18.39
TOTAL	64,7	100.00

FIG. 43. *Diagram of the leaf growth pattern polygonal and illustration of the* computation of the leaf pattern indices for the race Mochero.

a high value in Quadrant II indicates long and wide leaves; a high value in Quadrant III is indicative of long and narrow leaves; and a high value in Quadrant IV would suggest an overall growth pattern in the direction of short and narrow leaves.

Plant Internode Pattern. Diagrams were obtained after measuring a variable number of plants per collection having the modal collection number of nodes. Averages of collections with modal racial node number were used for final diagrams. Successive internode lengths in cm. were plotted against order of internodes from the bottom upwards. Tassels are represented by circles and upper ears by triangles. Scaling in our diagrams conforms to those of most of the previous publications in this series, that is, the abscissas indicate successive internode positions, while the ordinates show internode lengths.

Interesting characteristics of these diagrams are: (a) single high peak present in most Andean high-altitude races, (b) multiple peaks in lowland jungle and some coastal races; (c) continuously ascending polygonal in some primitive highland races; (d) long, upright last internode or tassel peduncle in most highland races,

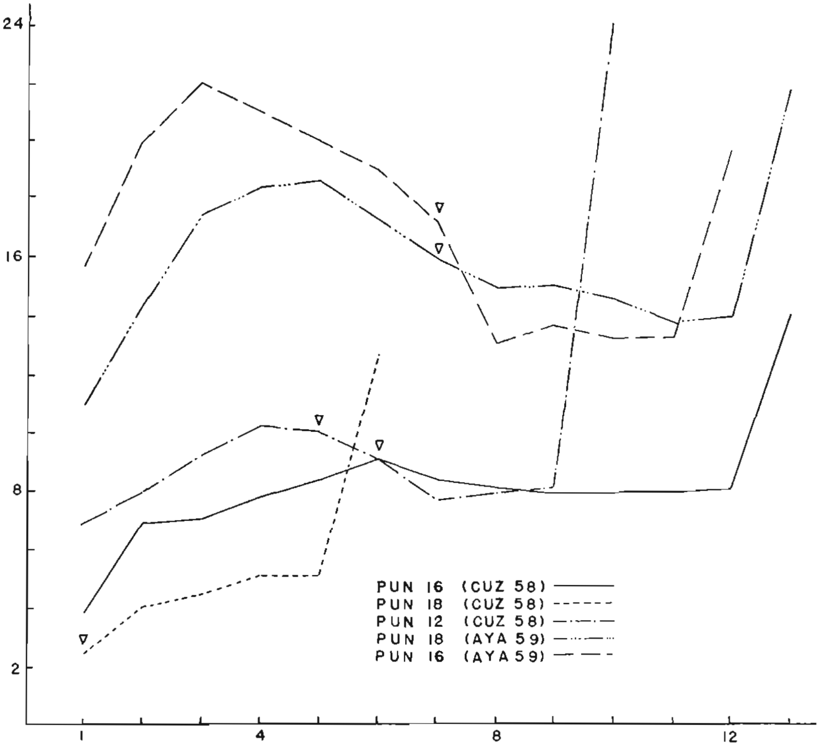


FIG. 44. Uchuquilla, internode-length diagrams for three typical collections. Two of them were grown at two different locations and years (Cuzco, 1958 and Ayacucho, 1959) resulting in different diagrams. The long last internode (tassel peduncle) was a constant feature. The abcissa shows the order number of the internodes, from the base of the plant upwards; the ordinate is scaled in centimeters, corresponding to the length of each internode. The triangle indicates position of the ear in this and following internode-length diagrams.

while lowland races generally have a much shorter last internode.

Evidence is available to indicate that plant internode patterns have diagnostic efficiency only when data are obtained from plants growing in an environment similar to that of their original habitat. In Fig. 44 we present a comparison between two collections of the race Uchuquilla grown in successive years at Huanta, Ayacucho, (2,300 meters above sea level) and at Cuzco (3,200 meters). It may be seen that at the higher altitude plants of both collections had internode growth patterns which, when expressed as diagrams, took the shape of rather flattened polygonals with slight upward trend, and terminated in a relatively very long tassel peduncle. The same collections grown at a lower altitude, with a much higher mean daily temperature, allowed greater overall plant growth and gave entirely different internode diagrams. These were characterized by high peaks, resulting from continued growth of the lower internodes. At both locations, however, there was constancy in the length and sharpness of the angle at which the diagram trace of the tassel peduncle deviated from the internode polygonal.

Stalk Width. This value is the average of 10 plants per collection over all those collections representing the race, taken at the middle of the first internode above ground, before harvest.

Prop Roots. Each whorl of prop roots above ground was given a score of one, that is, a plant with three whorls of prop roots would have a score of three. Each collection mean averaged the values of ten plants, and racial means averaged the values of typical collections.

Tillers. Number of tillers per plant was averaged for ten plants per collection, over all typical collections representing the race.

Pubescence. A score from zero (no pubescence) to three (strong pubescence) was given as a collection average. Letters following the score indicate whether the hairs are relatively soft (S) or hard (M).

Color. The most frequent adult plant (leaf sheath) color, whether green (V), sun red (RS), diluted sun red (RSD), or purple (P) is listed in Table 2A and in the text.

Rust and Helminthosporium. Degree of resistance is expressed on the basis of a score-scale ranging from one (resistant) to four (very susceptible).

Seedling Color Index. Seedlings from typical collections of each race were scored for presence and intensity of anthocyanin pigmentation in the coleoptile, leaf sheath, auricles, midrib, margins and tip. The scores were pooled and weighted to give an index of overall pigmentation which would range from zero (lack of anthocyanin) to 10 (strong pigmentation in all the above mentioned parts).

CHARACTERS OF THE TASSEL

Length of Peduncle. This is the distance measured in centimeters from the uppermost node of the stalk to the lowermost branch of the tassel. This is one of the characters most signficantly associated with the altitude of the original habitat of each race in Peru. High-altitude races have a long peduncle, while lowland races generally have a shorter peduncle.

By combining in a system of Cartesian coordinates the presentation of the length of tassel peduncle and the sum of the lengths of all (vegetative) internodes, exclusive of the peduncle, and plotting average values for all races, we obtain a scatter diagram, where an effective spacial separation is made between races (Fig. 45). In such a scatter diagram, all primitive races fall in the region of low total internode length and long tassel peduncle. Races of the Coast lie, in general, towards the other extreme in the plane marked by the two axes. Closely related races appear together in different areas of the plane limited by the coordinates.

Tassel Length. The length was measured in centimeters from the point of origin of the lowermost branch to the tip of the central spike. Coastal races generally have the longer tassels.

Length of Branching Space of Tassel. This is the distance between the point of insertion of the basal and the uppermost branch along the axis of the tassel.

Percent of Branching Space. This is the length of the branching space relative to total tassel length, expressed in percentage.

Branching space appears to be primarily, although not necessarily always, correlated with the number of primary branches. Thus, primitive races are among those having the lowest length and also the lowest relative percentage of branching space.

Length of the Uppermost Primary Branch. This is self-explanatory; in general, coastal races have the largest measurements in this character.

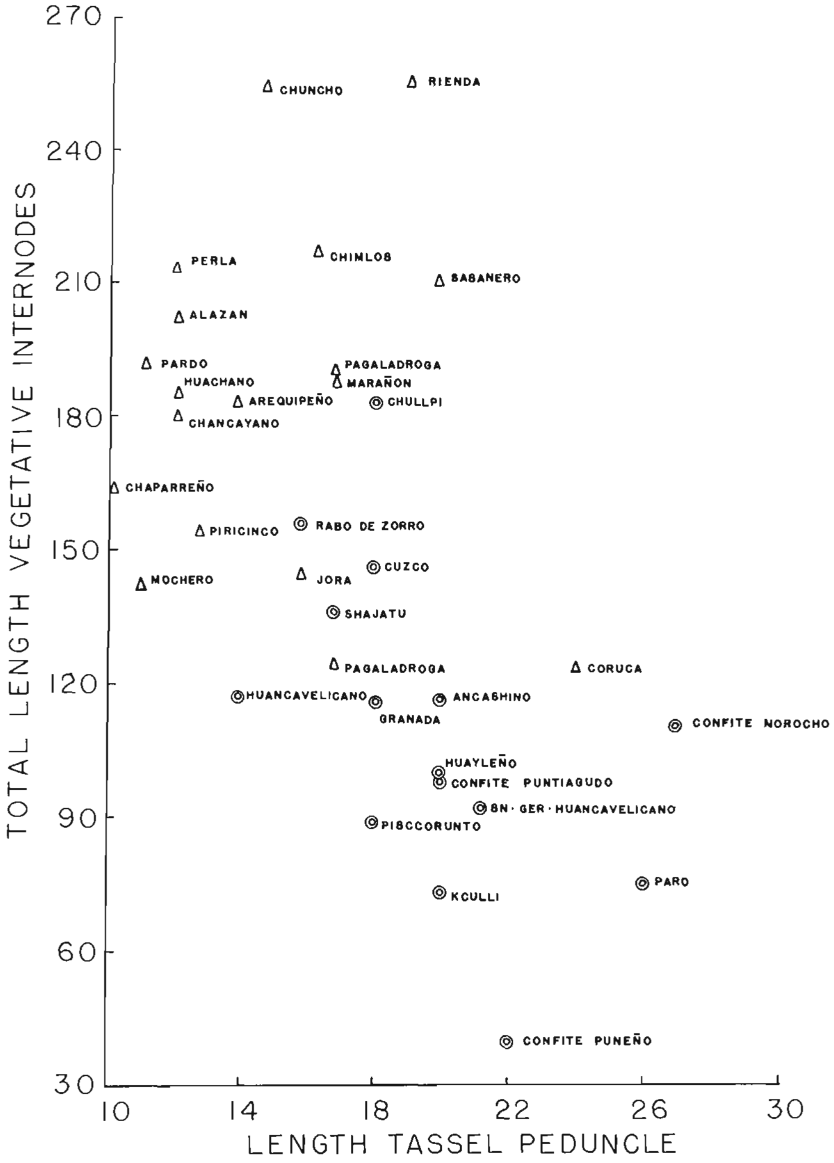
Characters of the Longest Primary Branch. Length, total number of secondary branches, and total number of tertiary branches. Each of these was averaged on measurements or counts of ten tassels per typical collection, over the range of typical collections of the race.

Total number of Primary Branches. Self-explanatory.

Total number of Secondary Branches. These were counted regardless of position. More than one secondary branch per primary was often found.

Total number of Tertiary Branches. The total number was counted regardless of position.

Condensation Index. This was determined as described by



45

FIG. 45. Scatter diagram of distribution of mean racial values of tassel peduncle length and total internode length, below the peduncle. Related races fall, in general, close together. Highland and more primitive races are in the lower right area. Coastal races and more evolved races are distributed in the upper left area.

Anderson (1944) and Wellhausen *et al* (1952). Save for rare exceptions, the condensation values for most of the Peruvian races are low.

EAR CHARACTERS

In the present study, information concerning ear characters has been as useful or more so than any other for the purpose of describing races of maize. The variabilities of ear characters are, in general, lower than the variabilities of tassel and plant characters (Brieger *et al,* 1958), and thus afford more reliable standards for typifying individual races. Data on the ear characters used in the present study were obtained, whenever possible, from original ears, and chiefly from first or second sib generation ears of collections breeding true to type. Some inbreeding may have ensued, therefore, reducing the magnitude of the average figures presented here. Examination of the data, however, did not show this reduction to be serious.

EXTERNAL EAR CHARACTERS

All measurements were made successively on ten ears per collection and averaged over all typical collections of a race. A summary of the data appears in Table 5A.

Ear Length. Self-explanatory.

Ear Width. This is measured at the midpoint of the ear length. (see *Ear Diameter,* Internal Ear Characters).

Ear Tip Diameter. This is measured about two cm. below the tip of the ear.

Ear Base Diameter. This is measured at the maximum diameter of the base of the ear.

Number of Rows. This is given as an average of the actual row count. Approximations to the nearest apparent row number were used when no distinct rowing was evident. In the latter cases the approximate row number is given followed by the indication *Irreg.*, or *Ir.* in Table 5A, and it is also indicated in the text.

Shank Length. This is measured from the point of its attachment to the stalk to the base of the ear.

Shank Width. This is measured on the internode nearest to the base of the ear.

Number of Shank Internodes. Self-evident. The shank node number is equivalent, within certain limits, to the number of husks. However, normally there are more husks than distinct ridges on which they are borne (Stephens, 1948).

CHARACTERS OF THE KERNELS

Kernel Length. This was measured on ten shelled kernels from the middle of the ear, laid side by side over graph paper divided in millimeter squares.

Kernel Width. This was measured in the same manner as kernel length.

Kernel Thickness. Measurements were taken with calipers on ten consecutive unshelled kernels from the middle of the ear.

Kernel Denting. A visual score was employed ranging from zero to three for no denting to deep denting, respectively, and was applied to each ear.

Kernel Striation. The longitudinal markings impressed on the kernel caps by the veins of the inner husk surface were given a score ranging from zero (no striation) to three (strong striation).

Kernel Hardness. Visual estimates were based on the texture of the kernel as appraised in a longitudinal section. Scores are: 1, Flint (Hard); 2, Semi-Flint (Semi-hard); 3, Floury (Soft).

Pericarp and Cob Colors. From three to ten ears per collection were scored for pericarp and cob colors and classified into phenotypic classes, according to visual similarity to the combined effects produced by the various alleles at the A_1 and P loci, and by the genes Pl and r^{ch} as described by Emerson, Beadle and Fraser (1936). The relative frequency of each class averaged over all the typical and sub-typical collections of each race is given in Table 6A.

These genes are located on different chromosomes, (A_1 on chromosome 3, P on chromosome 1, Pl on chromosome 6 and r^{ch} on chromosome 10). The first two have a combined number of at least 13 alleles, producing an array of easily identifiable phenotypes. It is quite obvious, therefore, that a combined phenotypic scoring for the four loci would involve linkage with other character differences between races extending over at least one-third of the chromosomes of maize.

INTERNAL EAR CHARACTERS

The comparison of data on the internal characteristics of the ears of Peruvian races complemented the use of external characteristics for describing the races, and proved to be much more valuable than the latter in establishing racial relationships. Data on internal ear characters are shown in Table 8A.

Ear Diameter. This type of measurement is the same as for ear width, indicated under *External Ear Characters.* It appears in both Table 5A and Table 8A. The reason for its being repeated is that it corresponds to new sets of measurements obtained on new ear samples, after it was decided that additional characters were required for proper differentiation of the races. The rest of the measurements appearing in Table 8A are related to those of Ear Diameter, since they come from the same ears, but are not related to those appearing under Ear Width in Table 5A.

Cob Diameter. This was measured from the center of the upper surface of the upper glume on one side of the cob to the corresponding point on the upper surface of a glume directly opposite.

Rachis Diameter. This was measured with calipers on the lower half of the broken ear. The measurement was made from the base of an upper glume on one side of the cob to the base of an upper glume directly opposite. Since the base of the glume is usually somewhat below the rim of the cupule, this measurement does not represent the maximum diameter of the rachis, but rather its diameter to the points at which the upper glume arises.

Pith Diameter. This was measured with calipers on the surface of the lower half of the broken ear, averaging the greatest and smallest diameters.

Rachilla Length. Accurate measurements of rachilla length can be made only in histological sections, but a very good estimate can be obtained from the data already available. (For an accurate method involving microslide projection, see Lenz, 1948.) The diameter of the rachis is subtracted from the diameter of the ear and divided by two. From the figure so obtained is subtracted the average length of kernel. The difference represents the average length of the rachilla from the base of the glume to the base of the kernel. No definite relationship between rachilla length and relative Tripsacum introgression was found in the Peruvian maize races.

Cob/rachis Index. This is computed by dividing the diameter of the cob by the diameter of the rachis. This index proved to be particularly useful in determining the phylogenetic affinities of races derived from Confite Morocho, which has the largest cob/

rachis index. A large cob/rachis index is indicative in Peruvian races of a very slender rachis with otherwise normal length glumes, while in Middle American corn it points rather to long glumes on an average-sized rachis.

Glume/kernel Index. This index gives a measure of the length of the glume relative to the length of the kernel. It is computed by subtracting the diameter of the rachis from the diameter of the cob and dividing the figure obtained by twice the average length of the kernel. This index provides an indication of the phenotypic effects due to alleles at the $Tu - tu$ locus ($Tu =$ tunicate; $tu^h =$ half tunicate; and $tu =$ normal) in interaction with their modifiers. A high glume/kernel index is found in Perla and all the coastal races related to it, and in Confite Puntiagudo and Piricinco, which are races with a high degree of phenotypic expression of tripsacoid characters. It is suggested, therefore, that the glume/kernel index is a good indicator of the degree of Tripsacum introgression in South American races of maize. Furthermore, this index appears to apply exclusively to *Tripsacum australe* introgression, since the imported races of the Tuxpeño complex, which show introgression from Middle American Tripsacum species, have, in Peru as well as in Mexico, relatively low indices.

Rachilla/kernel Index. This is the length of the rachilla relative to the length of the kernel. Since they have relatively long kernels, the races from the highlands possess a small rachilla/kernel index; the contrary is true for lowland races. Other than these, no other trends could be shown with certainty in Peruvian maize races.

Lower Glume Length. This was measured with calipers held perpendicular to the abaxial edge of the glume. Nickerson (1953) used this same measurement, referring to it improperly as "width" of the lower glume.

Lower Glume Pubescence. The relative density and length of hairs on the lower glume, were observed under a stereoscopic dissecting microscope, and given a visual score as follows: 1 = none to slight, 2 = intermediate, 3 = very pubescent.

Lower Glume Texture. The texture of the lower glume was classified on the basis of relative hardness when punctured with a needle. The scale of scores ranges from: 1 = very soft, to 4 = very hard.

Upper Glume Length, Pubescence and Texture. Measurements and scores are similar to the corresponding characters of the lower glumes.

Upper Glume Venation. A visual score was given, based on the number and prominence of surface ridges, i.e., 1 = low venation; 2 = intermediate venation; 3 = high venation.

Cupule Length. This measurement was taken in mm. with calipers placed over the cupule and paralleling the cob axis. Races derived from Confite Morocho have long, boat-shaped cupules.

Cupule Width. This measurement was taken as suggested by Nickerson (1953) by holding the calipers at right angles to the cob surface and measuring the distance in millimeters between any pair of outside rachis-flap edges across their cupule. Wide cupules correspond to wide kernels.

Cupule Depth. This measurement was taken in mm. on exposed cupules appearing in a section through the middle of the cob from their bottom to the upper level of the rachis flaps.

Cupule Pubescence. This was visually scored by observing the cupules with a dissecting microscope. The scale ranges from 1 = slight pubescence to 3 = strong pubescence.

Height of Rachis Flaps. The rachis flaps are outgrowths of the margin of the cupule, varying in prominence in different maize races (Lenz, 1948). They were measured in mm., with calipers held perpendicular to the axis of the cob, in a cross section through its middle. This procedure is shown graphically by Nickerson (1953).

Lenz (*ibid*) suggested that the presence of long rachis flaps is a tripsacoid characteristic and is correlated with other such characters. Cutler and Cutler (1948) found no association of height of rachis flaps with presence of or absence of certain knob positions in Guatemalan and South American corn.

In these studies a consistent low height of rachis flaps has been found in the group of races related to Cuzco. Otherwise the differences between races were not large enough to indicate any consistent trend of association of height of rachis flaps with either Tripsacoid influence or relative antiquity of each race.

Rachis Induration. This character was evaluated subjectively and scored from 1 to 4, the lower value corresponding to a soft rachis and the higher to a highly indurated (presumably high sclerenchymatized) rachis. The variability of these measurements is very high on account of the high subjectivity involved in scoring the degree of induration.

CYTOLOGICAL CHARACTERS

INTRODUCTION

A variable number of plants per collections, usually one to three, over a range of one to seventeen collections per race, provided young tassels for the study of microsporocyte chromosomes in the pachytene subphase of meiosis. These microsporocytes located in the anthers of the tassels were killed and fixed in a 3:1 absolute alcohol-acetic acid mixture, avoiding as far as possible sun heating in the field. After 48 hours they were transferred to 70 per cent alcohol. The samples were refrigerated at 4°C soon after they had been collected and were later permanently stored at near — 10°C at La Molina. The preparations were stained with propionic-carmine and observed in succession over a period of several months.

Each race was scored for frequency of terminal or subterminal knobs on each arm of every chromosome; the knobs were also classified in regard to their homo- or heterozygosis and to their size. For the purpose of computing frequencies, either a homozygous or a heterozygous knob was counted as one.

B-chromosomes, or supernumerary chromosomes, were counted in diakinesis, after being detected in the pachytene substage of meiosis.

THE VALUE OF CYTOLOGICAL CHARACTERS IN DETERMINING RELATIONSHIPS

Chromosome Knobs. The use of cytological characters as discriminants in studies of classification of maize races has proven to be of considerable value in this, as well as in previous studies on maize races from other countries. The particular usefulness of the cytological characters stems from the fact that they could not be subjected to the direct selection pressure of the Indian farmers (assuming that such characters as number of chromosome knobs and number of B-chromosomes are largely independent of yield in a given region). Therefore, the existence of any similarities between races in regard to such characters may be employed as additional indicators of their affinities. McClintock (1929) first established that the chromosomes of maize have large, bulky, heterochromatic regions called knobs, visible in meiotic prophase, and located in definite and characteristic positions. Longley (1937, 1938, 1939) determined the positions of these knobs in maize and in teosinte chromosomes. Twenty two such positions were reported by Rhoades (1955) in North American maize.

Previous cytological studies of maize populations (Mangelsdorf and Cameron, 1942; Wellhausen *et al*, 1952; Wellhausen and Prywer, 1954; Roberts *et al*, 1957) have correlated the average number of knobs per nucleus for each race or population with the degree of teosinte contamination. Tripsacoid maize, using the terminology of Anderson and Erickson (1941) to describe maize which exhibits phenotypic similarities to Tripsacum (presumably acquired from gene flow from teosinte as a bridging species) in Middle America has a high average number of chromosome knobs (Mangelsdorf and Cameron, 1942).

Tripsacoid maize in Peru, however, may have either high or low average frequency of presence of knobs, depending on whether Tripsacum species of the North American region or teosinte on one hand, or *Tripsacum australe* whose habitat is the tropical lowlands of several South American countries, on the other, are primarily responsible for the introgression. *Tripsacum australe* was reported to be essentially knobless by Graner and Addison (1944). However, a recent study (Ting, 1960) of a single plant of the same species from Colombia has shown that the chromosomes carry 5 large knobs and several other protuberances (up to 10) of a size bordering between large chromomeres or small knobs. These Tripsacum knobs, with a single exception, are terminal. Six of these are on chromosomes within the size range of maize.

In the present studies a total minimum number of 34 positions (at least 15 of which appear to be new) have been found over all the races of corn in Peru, extending the range of knob positions well beyond the previously known one (Fig. 46). Nine of the 15 positions are terminal. The largest number of known positions on a single race in Peru is 27, found in Perla, a low altitude race.

The implication is clear that knob positions other than those already present in North American maize have arisen in South America. It is suggested that the following possible explanations might account for the origin of such new knob positions: (a) introgression of knobbed races of *Tripsacum australe*, such as found

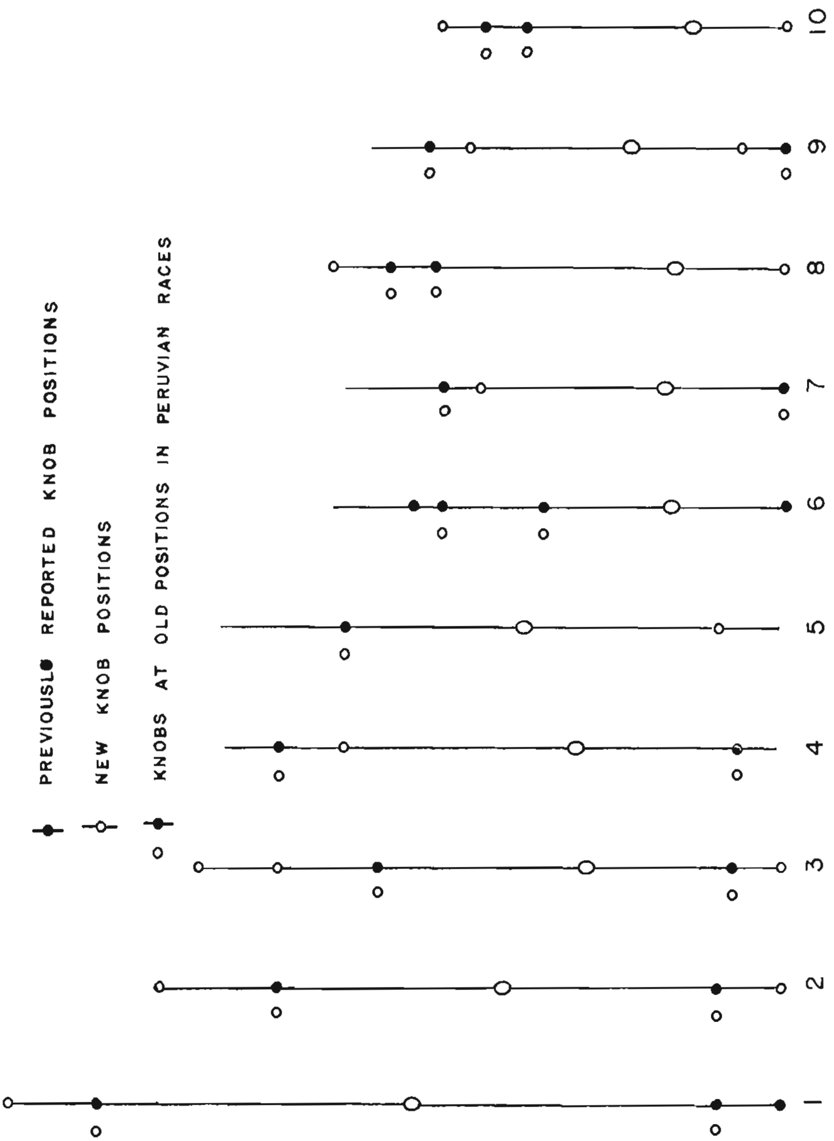


FIG. 46. Positions of chromosome knobs in the maize races of Peru. Fifteen new knob positions were found. Almost all of them were in two coastal races, Alazan and Perla.

by Ting, (*ibid*) contributing new knobs; (b) existence of a primitive knobbed race of maize in South America; (c) internal genetic mechanisms responsible for the transposition of knobs; (d) inception of knobs through mutation, recombination or position effects.

Maize races from the Sierra region have few knob positions and very small average frequencies of knob presence. A great majority of the highland races frequently carry a medium to small knob in an intercalary position on the long arm of chromosome 7, and less frequently a medium to small knob in an intercalary position on the long arm of chromosome 6. This pattern named "Andean" by McClintock (1959) was also consistently encountered by her in all plants of 30 highland races of Ecuador, Bolivia, and Chile where, however, every single plant carried an intercalary knob on 7L.[*] Such a consistency of the presence of a knob intercalary on 7L does not occur in Peru, where knobless-7 chromosomes, although rare, still are occasionally found. These appear in photomicrographs presented by Moreno (1960). Notwithstanding the absolute predominance of the Andean knob pattern in highland maize races in Peru, additional knob positions, particularly on 4L and 9L, both intercalary, have also been repeatedly found. Confite Puntiagudo, one of the primitive Sierra races, has the interesting feature of carrying knobs on 4L, 8L and 9L in several plants, in addition to the regular Andean 6L-7L pattern. These positions plus additional knobs on chromosomes 1, 2 and 5 were also found in Pisankalla, the Bolivian counterpart of Confite Puntiagudo, (Ramirez *et al*, 1960).

The frequencies of total number of knobs per chromosome complement averaged over all (Sierra) races are as follows:

0 knobs	23%
1 knob	54%
2 knobs	20%
3 knobs	4%
more knobs	0%

Low altitude races have, in general, a larger total number of knobs per complement as well as a larger diversity of positions where they may be present. Two distinct groups of races can be distinguished on the coast of Peru: (a) Anciently derived races and some more recent ones from highland floury races. This group

---

[*] Refers to chromosome 7 long arm.

has a knob frequency distribution strikingly similar to that of the highland races, as is indicated below. Frequencies have been computed for the following races: Mochero, Chaparreño, Chancayano, Huachano, Pardo, Pagaladroga.

0 knobs	29%
1 knob	46%
2 knobs	21%
3 knobs	4%
more knobs	0%

(b) Tripsacoid races. These exhibit a range of 4 to 14 knobs per complement, with a mode of 7 knobs. A large number of plants did not yield good counts on account of knob fusions. These have not been included in this range, and it is likely that their knob number is in the higher part of the range and perhaps extends beyond 14 (the range of knobs clearly accounted for, in the class of plants with knob fusion is 2 to 11 with a mode of 7 classified knobs). A comparative distribution histogram for number of knobs in both groups of coastal races is presented in Fig. 47.

These observations point to the interesting fact of the continued coexistence on the Peruvian Coast of races with both high and low chromosome knob numbers. It is apparent, too, that the introduction of higher knob numbers in Peru is a rather late event, appearing first on the North Coast, and extending thence to the Central Coast.

In the eastern lowlands of Peru, there are two distinct groups of races as regards chromosome knobs: (a) the native races, such as Piricinco, with a low total number of knobs (range 0-3), identical in knob number, frequency distribution and positions to Rabo de Zorro and Marañon, which are native to the valleys between the Central and Eastern Cordilleras of the Andes, and (b) races with high knob numbers, such as Chuncho, which can clearly be accounted for by introduction of maize from the northern part of South America, or from North America.

B-Chromosomes. Supernumerary, accessory or B-chromosomes were first identified in maize by Longley (1927) and Randolph (1941), although Kuwada (1911) had found that the number of chromosomes in cells of *Zea Mays* was not always constant.

The number of B-chromosomes in maize complements is maintained variable by a phenomenon of non-disjunction at the second

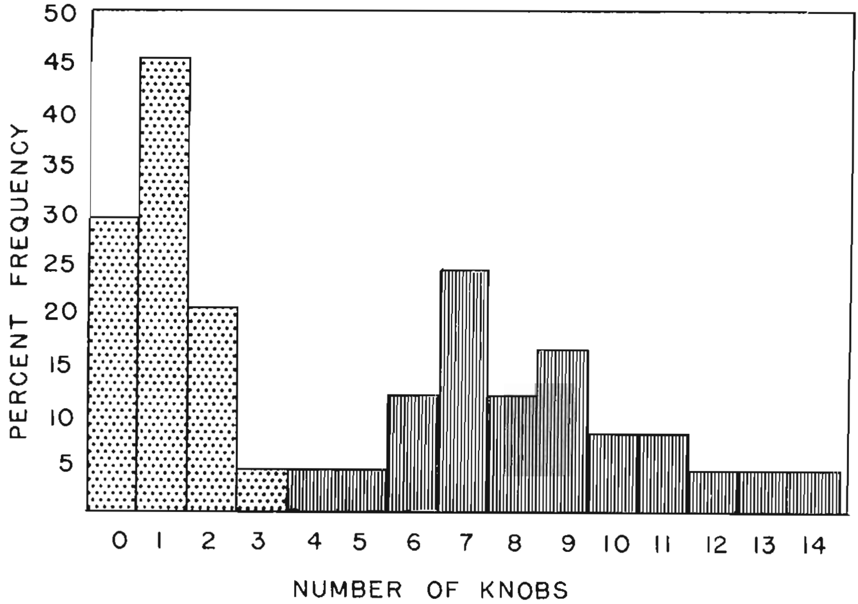


FIG. 47. Frequency histograms for total number of chromosome knobs in coastal maize races. The stippled histogram represents the pooled frequencies of the non or moderately tripsacoid races Mochero, Huachano, Chaparreño, Chancayano, Coruca, and Pardo. The striped histogram represents the pooled frequencies of the highly tripsacoid races Alazan, Perla, Rienda, Jora, and Arizona. The two frequency distributions do not overlap.

mitosis of pollen grains, described by Randolph and by Roman (1947).

Although no specific role has been assigned to B-chromosomes in maize, several suggestions related to their action in other plants have been advanced, and could be used as reference points for further research on their evolutionary role in maize. Darlington (1956 a and b) believes that B-chromosomes boost variability and hence the adaptability of a species. Lewis (1953) found a high correlation between presence of supernumerary chromosomes in *Clarkia* and its adaptation to arid regions. Fröst (1958) showed that *Centaurea* accessory chromosomes are also present in high number in plants from arid regions. In *Festuca pratensis*, Bosemark (1957) had evidence that one or two B-chromosomes were associated with increased vigor. In *Trillium grandiflorum*, introduction of 3 "euchromatic" accessory chromosomes favorably influenced seed fertility (Rustishauser, 1956). Müntzing (1958) concluded that commercial highly bred varieties of rye lacked

B-chromosomes, but that these were frequent in primitive strains in Asia. He also showed that the number of B-chromosomes in Asiatic rye populations when introduced into Sweden tended to decrease. The normal situation in Swedish rye varieties is an absence or rarity of B-chromosomes.

The variation in number of B-chromosomes in Peruvian maize is from 0 to 5 per cell. The number of B-chromosomes and their frequency is greater in high altitude races. In the coastal low altitude races, the tripsacoid group, with a high number of knobs exhibits a virtual absence of B-chromosomes, while in the non-tripsacoid floury races there is generally a greater frequency of B-chromosomes. In the eastern lowland races the same inverse relationship between number of knobs and number of B-chromosomes prevails.

DESCRIPTION OF EXISTING RACES OF MAIZE IN PERU

To be consistent with previous publications in the series on Races of Maize, we are using a classification of the Peruvian races of maize based on their chronological origin. The following groups are recognized:

1. *Primitive Races.* This group comprises races which on account of their morphological features, and almost generally on the basis of archaeological evidence, are considered to be of the greatest antiquity.
2. *Anciently Derived or Primary Races.* The races of this group are presumed to have been directly derived in the Pre-Columbian Epoch through isolation, hybridization and selection from the Primitive Races.
3. *Lately Derived or Secondary Races.* These are races whose origin can be traced back to Primary Races, and which appeared largely in the Post-Columbian Epoch.
4. *Introduced Races.* These races have been imported into Peru, and although they have already experinced gene exchanges with native races, they still maintain their distinct plant and ear morphology, which makes them recognizable as recent immigrants.
5. *Incipient Races.* These appear to be emerging at the present time as new racial entities, or have already become estab-

TABLE 8. General Classification of Living Races of Maize in Peru.

1. PRIMITIVE RACES
   - Confite Morocho
   - Confite Puntiagudo
   - Kculli
   - Confite Puneño
   - Enano
2. ANCIENTLY DERIVED OR PRIMARY RACES
   - Huayleño
   - Chullpi
   - Granada
   - Paro
   - Morocho
   - Huancavelicano
   - Mochero
   - Pagaladroga
   - Chaparreño
   - Rabo de Zorro
   - Piricinco
   - Ancashino
   - Shajatu
   - Alazan
   - Sabanero
   - Uchuquilla
   - Cuzco Cristalino Amarillo
   - Cuzco
   - Pisccorunto
3. LATELY DERIVED OR SECONDARY RACES
   - Arequipeño
   - Huachano
   - Chancayano
   - San Geronimo-Huancavelicano
   - Perla
   - Rienda
   - Marañon
   - Chimlos
   - Cuzco Gigante
4. INTRODUCED RACES
   - Pardo
   - Aleman
   - Chuncho
   - Arizona
   - Cuban Yellow Dent
5. INCIPIENT RACES
   - Jora
   - Coruca
   - Morocho Cajabambino
   - Morado Canteño
   - Sarco
6. IMPERFECTLY DEFINED RACES
   - Ajaleado
   - San Geronimo
   - Perlilla
   - Tumbesino
   - Colorado
   - Chancayano Amarillo

lished and well characterized in recent times. The races in this group are advanced in an evolutionary sense and have a restricted geographic distribution, which comprises one or few valleys or neighboring areas.

6. *Imperfectly Defined Races.* This is a group of races which have also limited geographical dispersal; some of these appear to be in an incipient stage of development. These races are sufficiently well characterized so as to be distinguishable from chance hybrid segregates, but the limited number of collections has not allowed us to specify their racial types with the same degree of accuracy as for the races of the previous groups. Only after addi-

tional collections are made and studied will we be able to either retain or dismiss them as distinct races.

In table 8 all the existing races of maize in Peru are listed under their respective categories, as described above.

These same maize races are shown again in Table 9 according to the approximate chronology of their appearance and to their distribution in the three great natural regions of Peru. The archaeological races that preceded the modern races in each region are also shown in this Table.

TABLE 9. Classification of Modern and Some Archaeological Races of Maize in Peru Based on Approximate Chronology of Appearance and on Geographical Distribution.

Coast	*Sierra*	*Selva*
	PRIMITIVE RACES	
Archaeological	*Archaeological*	
Confite Iqueño	Proto-Confite Morocho	
	Confite Chavinense	
	Proto-Kculli	
	Proto-Confite Puntiagudo	
	Modern	*Modern*
	Confite Morocho	Enano
	Confite Puntiagudo	
	Confite Puneño	
	Kculli	
	ANCIENTLY DERIVED RACES	
Archaeological	*Archaeological*	
Proto-Mochero	Proto-Chullpi	
Proto-Pagaladroga	Proto-Ancashino	
Proto-Alazan	Proto-Paro	
Proto-Rabo de Zorro	Proto-Uchuquilla	
Proto-Ancashino	Proto-Cuzco	
Modern	*Modern*	*Modern*
Mochero	Huayleño	Rabo de Zorro*
Pagaladroga	Chullpi	Piricinco
Chaparreño	Granada	
Alazan	Paro	
	Morocho	
	Huancavelicano	
	Rabo de Zorro*	
	Ancashino	
	Shajatu	
	Sabanero	
	Uchuquilla	
	Cuzco Cristalino Amarillo	
	Cuzco	
	Pisccorunto	

TABLE 9. Classification of Modern and Some Archaeological Races of Maize in Peru Based on Approximate Chronology of Appearance and on Geographical Distribution (Continued).

Coast	*Sierra*	*Selva*
LATELY DERIVED RACES		
Modern	*Modern*	*Modern*
Arequipeño	San Geronimo-Huancavelicano	Marañon*
Huachano	Marañon*	Chimlos
Chancayano	Cuzco Gigante	
Perla		
Rienda		
INTRODUCED RACES		
Pardo		Aleman
Arizona		Chuncho
Cuban Yellow Dent.		Cuban Yellow Dent.
INCIPIENT RACES		
Jora	Morocho Cajabambino	
Coruca		
Colorado		
Chancayano Amarillo		
Morado Canteño		
IMPERFECTLY DEFINED RACES		
Tumbesino	Ajaleado	Perlilla*
	San Geronimo	
	Sarco	
	Perlilla*	

* Indicates that this race overlaps the transition area between the two regions where it is listed.

PRIMITIVE RACES

A group of distinct races, possessing what are considered to be "primitive characters," (Sturtevant, 1899; Mangelsdorf and Reeves, 1939), is perfectly well defined in Peru.

Such primitive characters are, in general, earliness of maturity, short plants and tassels, high leaf venation index, small ears, long glumes, small kernels, slender cobs, simple cob structure, large cupules, little induration of the rachis tissue, etc.

The Primitive Races of Peru, like those of other countries, were all popcorns, and some of them have persisted until present times. Other races grown in pre-Columbian times which are still in existence today, were not popcorns. However, races in this latter group are not considered to be primitive since they appear to have been derived in prehistoric times from other ancestral races, which are either known now or whose existence may be surmised from logical inference. Bearing in mind that their antiquity may also date back to prehistoric times, they will be dealt with separately as Anciently Derived Races.

CONFITE MOROCHO

Plants (Fig. 51). Very short, approximately 127 centimeters; very early in maturity, 116 days to mid-flowering when grown at high altitudes, and 112 days at medium altitudes; second earliest race after Confite Puneño at high altitudes; average number of leaves 11.9; length of the ear leaf 53.4 cm.; width 6.3 cm., very narrow; average number of veins 24.0; venation index one of the highest of all races, 3.8; leaf area small, 2,674 sq. cm.; no tillers; plant color sun red; pubescence lacking; ear located in the middle of the stalk at a height of 56 cm.; resistant to Helminthosporium, but susceptible to rust.

Cytological Characteristics. One small knob subterminal on chromosome 7 long arm, with a frequency of 100%; one small

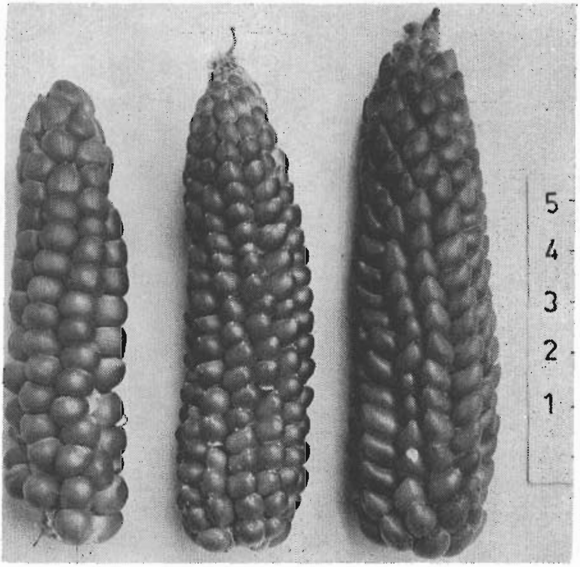


FIG. 48. Confite Morocho (Aya. 20 left, Aya. 4 center and right). This popcorn is a living relic of an ancient Central Andean race. Proto-Confite Morocho, from which most of the South American corn races are descended. This and all the following figures showing typical ears of the described races are reproduced three fourths natural size.

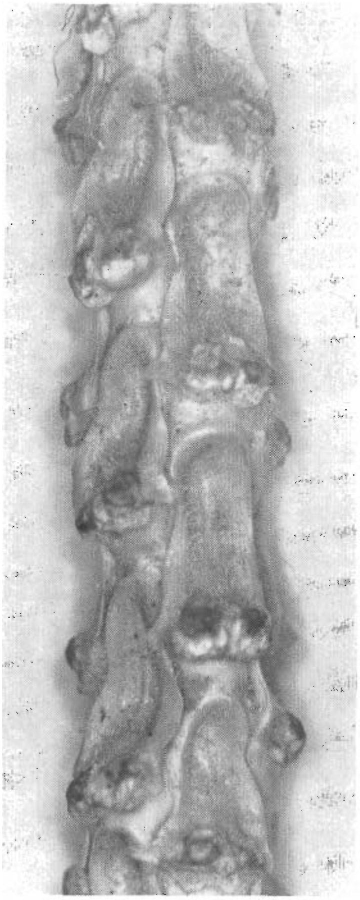


FIG. 49. Simple and very slender cob of Confite Morocho showing its long, narrow, and boat shaped cupules, and its prominent rachis flaps. Note the interlocking of the cupules. (About 3.5 x natural size)

knob subterminal on chromosome 6 long arm, with a frequency of 25%; B-chromosomes were not found.

Tassels. (Fig. 50). Longest peduncle of all races, 27.2 cm.; branching space short; medium long central rachis, very few secondary branches, averaging 4.2 per tassel; tertiary branches absent; condensation index low, 1.00.

Ear, External Characters (Fig. 48). Short, cylindro-conical, slight taper at both tip and base; very slender cobs, average num-

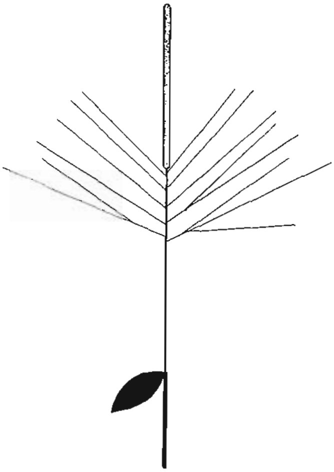


FIG. 50. Tassel diagram of Confite Morocho. This as well as the following tassel diagrams are reproduced to one ninth of natural size.

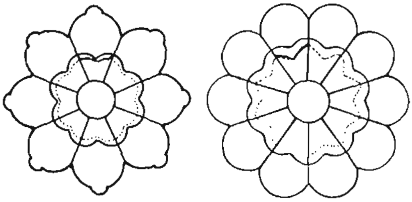


FIG. 52. Cross-section diagrams of 8-row (left) and 10-row (right) ears of Confite Morocho. All the ear-cross-sections in this publication are reproduced to natural size; they show the kernel outline, followed to the inside by the lower glume, and next by the upper glume outline, and finally in the center by the rachis outline. The full outline of one kernel is shown at the top. These diagrams are based on racial averages.

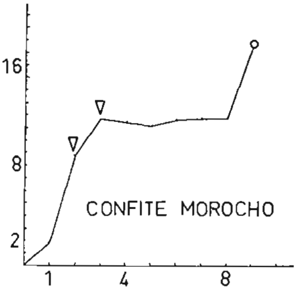


FIG. 51. Internode pattern of Confite Morocho. The circle indicates position of the tassel; the triangles indicate the position of the ears.

ber of rows, 8, usually regular; kernels often arising from spreading spikelets; midcob color 70% red, 30% colorless; very short shank with very low number of shank nodes, shank diameter shortest of all races, 0.42 cm; kernels small, usually pointed or beaked upwards, although round kernels are also found; denting absent; medium kernel striations; endosperm flinty pop type, yellow; pericarp and aleurone colorless; cob white; 100% absence of color of glumes and lemmas; staminate tip often present.

Ears, Internal Characters (Fig. 49, 52). Average ear diameter 26.3 mm.; average cob diameter 12 mm.; average rachis diameter 5.2 mm.; estimated rachilla length short, 1.4 mm.; cob/rachis index 2.30, highest of all Peruvian races; glume/kernel index low, 0.37; rachilla/kernel index low, 0.16; diameter of pith very low, 2.0 mm.; lower glume medium short, medium pubescence, chaffy and very soft, texture index 1.55, lowest of all Peruvian races; upper glume very short, slightly pubescent, texture very soft, thin and chaffy, intermediate in venation, very weakly pubescent; cupule very long, 3.1 mm.; very narrow, 2.9 mm. and rather shallow, weakly pubescent; height of rachis flaps medium; rachis tissue spongy; tripsacoid characters absent.

Distribution: Confite Morocho has been collected in the Departments of Ayacucho, Huancavelica and Junin, (Fig. 53), at altitudes that range from 2,500 to 3,000 meters above sea level, but a detailed search would probably disclose a wider distribution for it. Although its present center of concentration is the Department of Ayacucho, in past times it might have had a more extensive range, from Bolivia to Ecuador, in the intermediate elevations of the Andean valleys, and it was also probably carried down to the coastal valleys, where its earliness and resistance to extreme environmental fluctuations, stemming from a genetic background not yet evolved from environmental specifity, as is the case with some of the modern races, favored easy adaptation. Confite Morocho was later supplanted in most localities by a higher yielding popcorn race, Confite Puntiagudo. However, it is still grown for consumption in a popped form, and is planted in small patches. The Indian farmers of the Peruvian highlands have a good conception of the excellent popping characteristics of small, flinty kernels, and they practice a constant selection for this character, which helps in maintaining the identity of this race. Hybridization with other races is largely prevented by the difference in flowering time. Unlike other races, Confite Morocho has a higher market value when sold on the ear, than as shelled corn, a fact which also helps in the maintenance of a high purity standard.

Origin and Relationships. Confite Morocho has more extreme

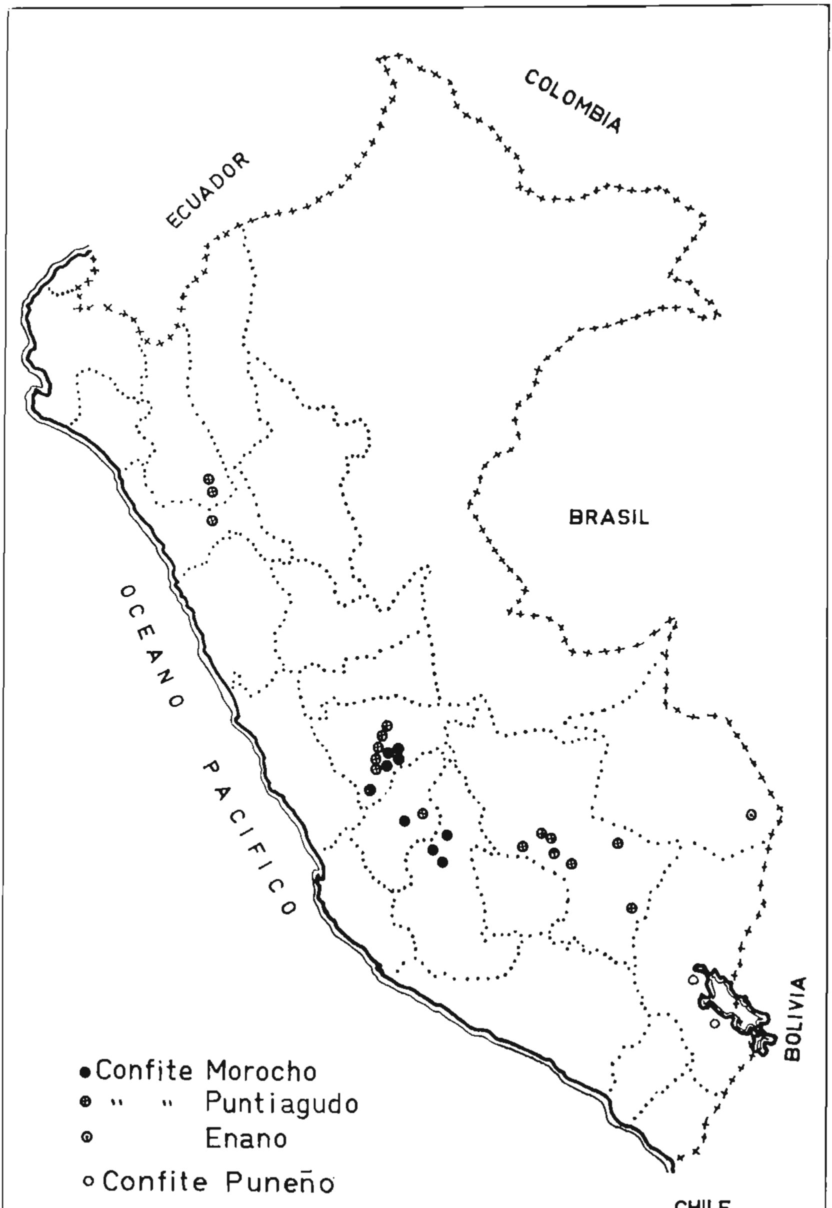


FIG. 53. Map showing the geographical distribution of the races Confite Morocho, Confite Puntiagudo, Confite Puneño, and Enano.

primitive characters than any other known living race of maize. It is one of the most ancient races, its existence tracing back in all likelihood to the first domesticated corn in Peru.

Primitive characters found in this race include the small flinty kernels; the extremely simple structure of the cob, which is basically an unmodified rachis on which the spikelets, with rather large and thin glumes, are implanted at the base of open, long, boat-shaped, interlocked cupules (Fig. 49). A large tassel peduncle, and a characteristic internode diagram with a middle plateau are also interesting features of this race. So are its very high cob/rachis index, very slender shank, and the small size of ear and plant.

Confite Morocho undoubtedly represents today an evolved form, little modified in cob structure, of the earlier cultivated maize race Proto-Confite Morocho, which existed during the Incipient Agricultural Epoch at the middle elevations of the south central Andes. Proto-Confite Morocho was the first domesticated corn of the Andes and must have been derived from a wild race of corn which had a cob rachis as slender as the rachis of the tassel, with long glumes, small, hard, pointed, red or brown kernels, and staminate spikelets in the upper part of the ear. The early populations of Proto-Confite Morocho were probably partially self-fertilized and phenotypically less variable than their derived populations in later periods.

Populations of a fasciated popcorn, Confite Chavinense, which did not otherwise differ much from Proto-Confite Morocho were the ancestors of all the globular ear shaped races of the Andes. Confite Chavinense may have arisen either from the immediate wild ancestor of Proto-Confite Morocho or as a parallel wild race.

The great majority of races of South America, including the Andes and neighboring low coastal areas and all the Amazon basin can ultimately be traced back in ancestry to Proto-Confite Morocho, the prehistoric counterpart of the race we are describing here. Such extremely differentiated races as Cuzco Gigante and the U. S. Corn Belt dent have a phylogeny that may be traced back to the lineage of Confite Morocho (Figs. 238 and 239). Several of the primitive popcorn races of South America (Proto-Pagaladroga and Confite Puntiagudo in Peru, Pisankalla and Kcarapampa in Bolivia, Pollo in Colombia, Chutucuno Chico and Polulo in Chile, and the popcorns of the Brazilian jungle) are probably related to Confite Morocho. All these races may have arisen through the breakdown of continuity of the distribution of the wild ancestor race or of Proto-Confite Morocho, with the resulting formation of *demes* (isolated populations) which were modified by natural selection to become adapted to their different concentration areas. Some of these *demes* were introgressed by Tripsacum in the periphery of the enlarged area of distribution of Proto-Confite Morocho, resulting in tripsacoid popcorn races such as Confite Puntiagudo, Pisankalla, and to a lesser degree Kcarapampa. Perhaps, Palomero Toluqueño of Mexico was derived from one of such populations which was carried to the north.

Existing races directly derived from Confite Morocho in Peru are Confite Puntiagudo, Morocho, Huancavelicano and Rabo de Zorro.

If it is assumed that the present area of concentration of Confite Morocho has always been its principal habitat, it may be easily grasped how well the morphological and physiological characteristics of Confite Morocho adapt this race to its environment. In the high valleys of the Ayacucho region of the Andes, high daytime and low night temperatures cooperate to produce a very high net assimilation rate, and consequently photosynthetic efficiency per leaf unit area may be high, requiring a relatively low leaf area per unit weight of carbohydrates produced. This also accounts for a selective advantage of low-leaf area against hail damage at high altitudes. The semi-arid conditions of this region, with a well defined rainy season and a long dry season, would require a plant that under negligible or poor human management in the early primitive agricultural periods, was early enough to make a crop within the limited period of a sufficient water supply, and which had morphological features adapted to low water consumption.

It is interesting to observe that the husk leaves of Confite Morocho, as well as those of its derived popcorn race, Confite Puntiagudo, open very easily, and remain partially opened after the ear dries. This is a characteristic nearer to that required for natural seed dispersal by wild corn, than is found in any other race.

A sub-race Confite Morocho de Huayucachi is grown at the higher elevations (near 3,200 meters) in the Mantaro valley. It has a more distinct straight row arrangement with 8 rows, and kernels more pronouncedly beaked than ordinary Confite Morocho, but resembles the latter in most of its other characters.

CONFITE PUNTIAGUDO

Plants (Fig. 58). Very short, average height 116 cm.; very early maturing, 136.7 days to mid-silking at high altitude locations, 114.7 days at middle-high altitudes, 83.7 days at middle-low altitudes, and 78 days at sea level; average number of leaves low, 8.7; short and narrow; average number of veins 23.9; venation index very high, 3.69; leaf area low, 2,356 sq. cm., from zero up to twelve tillers per plant; when present they are of the same height as the main stalk; plant color most frequently dilute sun red, slightly pubescent; height of ear 49 cm.; rather resistant to *Puccinia Sorghi;* susceptible to Helminthosporium blight.

Cytological Characteristics. Chromosome knob number low,

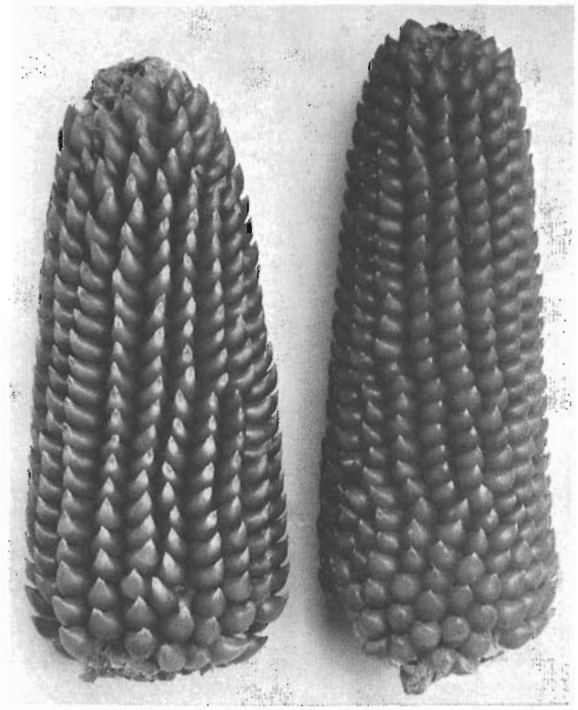


FIG. 54. Confite Puntiagudo (Cuz. 152). This primitive popcorn is grown in the middle to high elevations of the Andes from southern Colombia to northern Argentina.

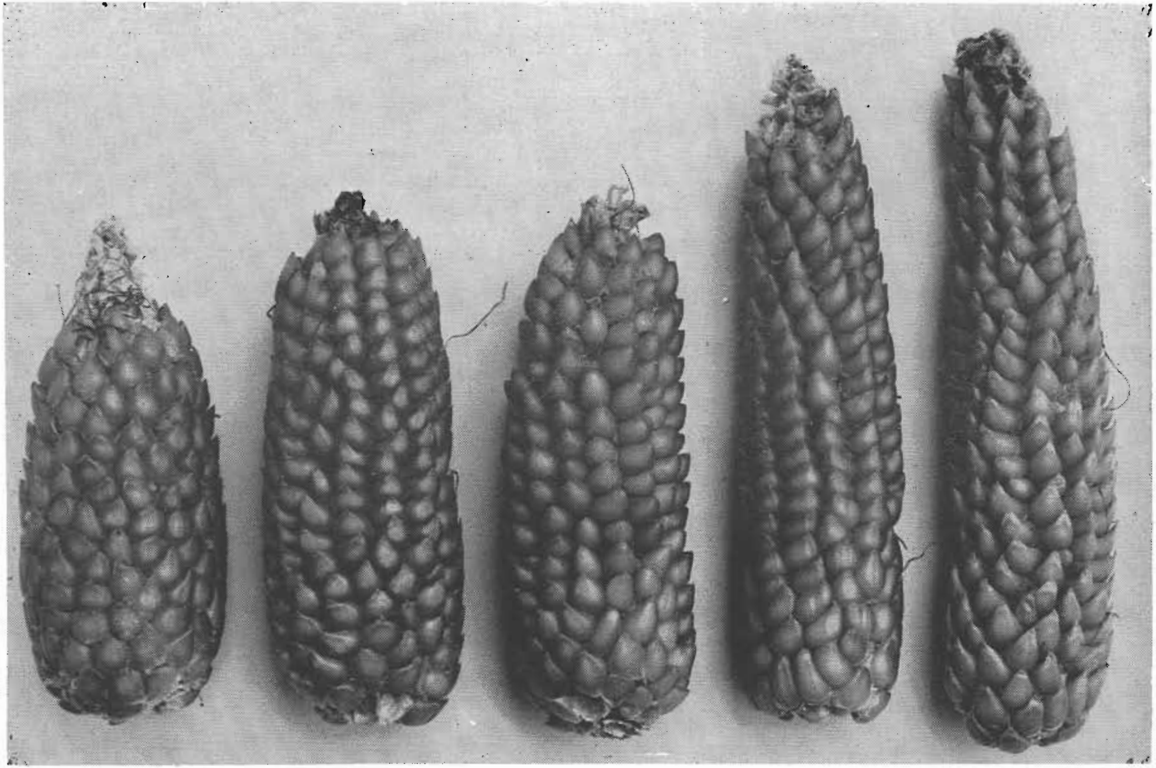


FIG. 55. Variation in a single collection of Confite Puntiagudo (Hvca. 147), from the longer, slender ears at the right, appoaching the type of Confite Morocho, to the short, wide ear at the left. This last one is similar to the ancestral popcorn Confite Chavinense.

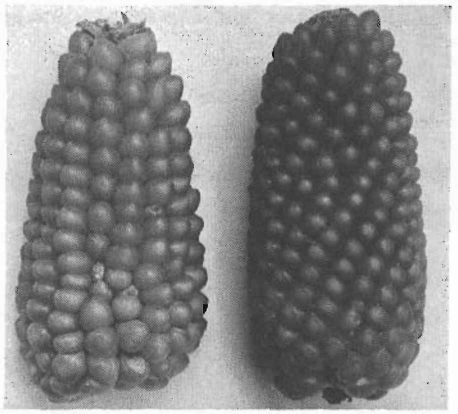


FIG. 56. Fasciated forms of Confite Puntiagudo from the North Sierra. Note the reduced imbrication of the kernels, and double-spiral kernel arrangement in the ear at the right, like that of prehistoric ears from the Coast of Peru.

0-2, with the most frequent positions on long arm chromosome 7, and next most frequent a medium sized knob on a subterminal position of the long arm of chromosome 4, and knobs on long arm of chromosomes 6, 8, and 9; one third of the plants studied had one or two B-chromosomes, the rest none.

Tassels (Fig. 57). Peduncle long; branching space short; central rachis medium short; low number of rather short branches; with few secondaries and tertiaries; condensation index low, 1.02.

Ears, External Characters (Figs. 54, 55, 56). Short and small diameter, cylindrical, slightly tapering at both ends; average number of rows high, 15.1; kernels frequently irregularly disposed, very often arising from spreading spikelets, with inverted embryos more often than any other race, arising from the lower florets which in most races are usually aborted; fasciated ears relatively very frequent; of small shank diameter, although definitely larger than in the preceding race, with low number of nodes, and intermediate length; husk leaves few in number, opening partially when ear matures; kernels small, of popcorn type, rather long in proportion to their width and thickness, almost always pointed and often beaked, whence its name (Puntiagudo, meaning pointed), with an unusual strong adherence of silks to the micropyle after maturity; no striations on the surface; white endosperm; colorless pericarp and white cob with a frequency of about 84%, colorless pericarp and red cob (*AP^{wr}*) 5%, variegated red peri-

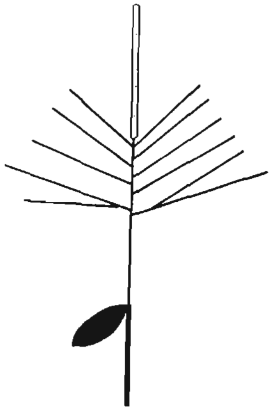


FIG. 57. Tassel diagram of Confite Puntiagudo.

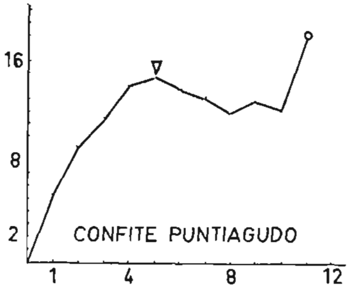


FIG. 58. Internode pattern of Confite Puntiagudo.

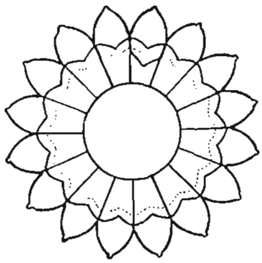


FIG. 59. Ear-cross-section diagram of Confite Puntiagudo.

carp and cob (AP^{vv}) 3%, light brown pericarp and cob ($A^{b'}P^{rr}$) 4.6%, and light brown pericarp and white cob ($A^{b'}$ P^{rw}) 3%. Limited tests have indicated absence of aleurone color inhibiting factors.

Ears, Internal Characters (Fig. 59). Average ear diameter 33.5 mm.; average cob diameter 21.6 mm.; average rachis diameter 12.6 mm.; pith diameter 6.5 mm.; estimated rachilla length short, 1.7 mm.; cob/rachis index medium, 1.71; glume/kernel intermediate, 0.52; rachilla/kernel index medium, 0.19; lower glume medium short, medium pubescence, texture index 3.15, very horny; upper glume intermediate in size, weak to intermediate pubescence, texture low to intermediate, regular to strong venation; cupule wide in relation to its length, but shallow, weakly pubescent; height of rachis flaps medium; rachis tissue slightly horny; tunicate allele tu^w; intermediate expression of tripsacoid characters.

Distribution (Fig. 53). The area of distribution of Confite Puntiagudo is one of the most extensive of the Sierra races, covering in its span the entire Andean highlands of Peru. However, this race occurs more frequently in the southern Andes, where it also appears in its most typical form. Material from the North Highlands (Cajamarca, La Libertad) tend to show reduced kernel imbrication. The altitude range of this race is from 2,500 to 3,500 meters above sea level, with greater frequency around 3,000 meters. It extends beyond the Peruvian area of the Andes into Ecuador and Colombia, where it has been described under the name Imbricado (Roberts *et al,* 1957), and to Bolivia and the northern Argentina Sierra, in both of which areas it is called Pisankalla, Pisingallo or Pisincho.

Origin and Relationships. Confite Puntiagudo has the morphological characters of a primitive race, resembling in many respects Confite Morocho. It differs from the latter in its conspicuously stronger tendency to tiller, and in certain ear characters such as a larger average row number and a higher degree of induration of the tissues of the glumes and rachis. The Indians of the Cuzco area recognize its primitiveness by naming it *Chili-Sara,* one meaning of which in Quechua is "Old Corn."

This race seems to be a direct derivative of Confite Morocho, with some Tripsacum introgression coming in probably through a bridging maize race, possibly Enano, from the Madre de Dios river basin, on the lowland eastern flanks of the Andes.

In fact, an imbricated popcorn variety has been found associated with Enano in the Tambopata river region of the Department of Madre de Dios in the southeastern jungle lowlands of Peru.

At any rate, Confite Puntiagudo approaches very closely the gross morphology of Confite Morocho, differing from the latter in tillering more profusely and in that selection has been effective in enhancing characters that are obviously correlated with increased yield potential, such as longer ears and increased number of kernel rows.

Brieger *et al,* (1958) in describing two Guarani popcorn races entertained the idea (see their p. 149, Fig. 70) that the so-called "South American Popcorn" (referring to Confite Puntiagudo), is derived from one of those races. A close comparison of their morphological data with that provided in this text for Confite Puntiagudo will disclose the more evolved nature of the Guarani popcorn especially regarding its more complex internode pattern. This is apparent in the length of the internodes above the ear bearing node (their Figs. 80 and 83), and also in the large number of nodes.

It is very interesting to compare Confite Puntiagudo with Palomera Toluqueño, a primitive popcorn from Mexico. Both races exhibit a strikingly similar plant architecture, and similar form and structure of ear and tassel. Biometrical measurements on many characters agree closely. They both have a low chromosome-knob number. Palomero Toluqueño and Confite Puntiagudo can easily be grown on the coast of Peru, and behave similarly under the conditions prevailing there. Apparently both races have a great range of environmental adaptability.

All these indications point to the possibility of a common origin of these two races, perhaps in the Central Andes. Subsequently, introgression of Tripsacum occurred possibly in South America and later in Middle America. Further changes in phenotype of the races that differentiated in both continents were kept to a minimum in their respective final habitats, due to rigorous selection for ear type and maintenance of earliness.

Confite Puntiagudo is always grown in small plots beside fields of floury corn, primarily for direct consumption on the farm, and very seldom for commercial purposes.

Derivation of name. From *Confite,* meaning a popcorn, and *Puntiagudo* meaning pointed. It is occasionally referred to as Pisankalla.

KCULLI

Plants (Fig. 62). Very short, average height 92 cm.; early, 137 days to mid-silking at high altitudes; average number of leaves 9.5; leaves short and narrow; venation index high, 3.31; leaf area 4,707 sq. cm.; leaf pattern index 85% on Quadrant II; tillers absent; plant colors range from dilute sun red to purple, with typical plants almost always colored deep purple; pubescence lacking; ear position low, 30 cm. from the lower node, with five leaves above the ear; resistant to *Puccinia Sorghi* in field tests at lower altitudes, moderate susceptibility to Helminthosporium leaf blight.

Cytological Characteristics. Number of chromosome knobs low, 1-2, 88% of samples with one small knob subterminal on long arm of chromosome 7; next most frequent knob positions are sub-

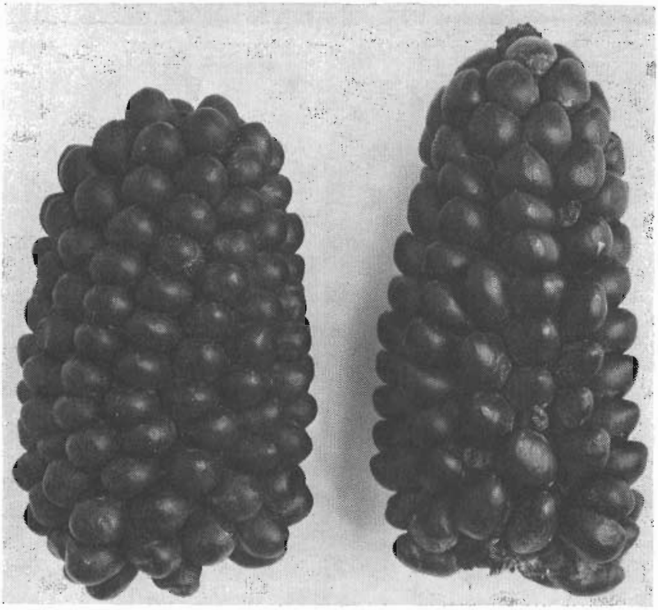


FIG. 60. Kculli (Cuz. 108). This race has small ears with characteristic clustered arrangement of large, rounded kernels with cherry pericarp color.

terminal on chromosome 6L,* and 4L, B-chromosomes found in 38% of plants studied, with a high frequency in these of 5, and a low of 2 B-chromosomes per cell.

Tassels (Fig. 61). Long tassel peduncle (exserted tassel), second only to Confite Morocho, 19.6 cm.; small tassel with very short branching space, 8.8 cm. and 22%; long central spike; very few branches, almost no secondaries and tertiaries; condensation index low, 1.00.

Ears, External Characters (Fig. 60). Short, spheroconic, tapering strongly towards the tip; intermediate width; average number of rows 12, irregularly arranged; short slender shank, husk number low, 8; kernels long, intermediate in width, often moderately imbricated, sometimes round, undented, with intermediate to low degree of surface striation; frequent abortion of kernel formation gives slight irregularity of appearance of kernel arrangement; endosperm white, very soft, floury, rarely with purple aleurone, midcob color present in all ears examined; glumes colored purple in ⅔ of ears, and lemmas colored in all; pericarp and cob colors

---

* We shall refer from here on to 6L as long arm chromosome 6, S short arm, etc.

very deep cherry-purple in most of the ears studied, ($AP^{rr}\ Pl\ r^{ch}$) 48%, red-red (AP^{rr}) 10%; cherry-red ($AP^{rr}\ r^{ch}$) 1.5%, colorless-red (AP^{wr}) 10% variegated red-variegated red (AP^{vv}) 3%, brown-brown ($A^{b\prime}P^{rr}$) 4.5%, brown white cap-brown ($A^{b\prime}\ P^{cw}$) 3%, colorless-white 19%.

Ears, Internal Characters (Fig. 63). Average ear diameter 64.9 mm.; average cob diameter 21.3 mm.; average rachis diameter 15.2 mm.; estimated rachilla length very short, 0.8 mm.; cob/rachis index lowest of all Peruvian races, 1.40; glume/kernel index smallest of all Peruvian races, 0.20; rachilla/kernel index very small, lower glume 3.1 mm. in length, low to intermediate in pubescence, intermediate in hardness; upper glume shortest of all Peruvian races, 2.8 mm., without pubescence, very soft, intermediate in venation score; cupule short, wide, very deep, slightly pubescent; height of rachis flaps medium; rachis induration low; Tripsacoid characters absent.

Distribution (Fig. 64). The area of dispersal of Kculli is the south central Andean region, especially the Departments of Junin, Huancavelica, Apurimac and Cuzco, but samples have been collected as far north as the Sierra of Cajamarca. Although it has been found at altitudes of 2,300 to 3,300 meters above sea level, the great majority of typical collections originated at altitudes in excess of 3,000 meters.

There is a widespread use of Kculli corn for dyeing foods and beverages especially unfermented *chichas* and *mazamorras,* the latter are maize and tapioca flour jellies.

Origin and Relationships. Kculli shares very closely the geographical distribution of two other primitive races, Confite Morocho and Confite Puntiagudo, both in respect to altitude and latitude. It shares with them also several primitive characters, such as long tassel peduncle, low tassel branching and high venation index. However, it differs from those races in its small cob-rachis and glume-kernel indices, resulting from the very short glumes of Kculli, and it also has a much smaller rachilla length, which gives it an expected small rachilla-kernel index.

Ceramic evidence of the existence of Kculli as a race in pre-Columbian times is available both on the coast and in the Sierra (Fig. 40). Clay and stone ear replicas show the characteristic grape-like clusters of large round kernels. The abundant representations would seem to be the logical consequence of the high utilitarian regard which ancient Sierra farmers had for this type

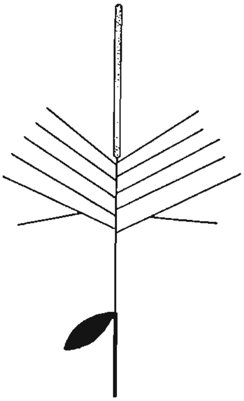


FIG. 61. Tassel diagram of Kculli.

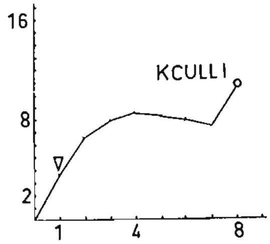


FIG. 62. Internode pattern of Kculli.

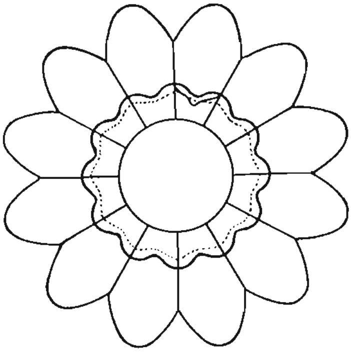


FIG. 63. Ear-cross-section diagram of Kculli.

of corn. It is interesting to notice the close resemblance of their designs with the actual modern type for the race.

Evidence for the existence of Kculli as an early distinct race is obtained from the maize of several archaeological areas exhibiting cherry pericarp color. In Los Cerrillos it appears with a frequency of about 5%, in Ocucaje 23%; Paracas 4%; and Nazca 4.6%.

At the early agricultural level at Los Cerrillos in the Ica valley, Kculli occurs as a popcorn, Proto-Kculli, with ears possessing a higher length-width ratio than the rest of the population.

Proto-Kculli may well have been an ancient popcorn race of the Andes, no longer in existence and represented in later prehistoric periods and today by its derived floury race Kculli.

Derivation of name. From the Quechua word *Kculli* (pronounced K'hulli), meaning black. It is the common name given by the Indians to black dye-corn.

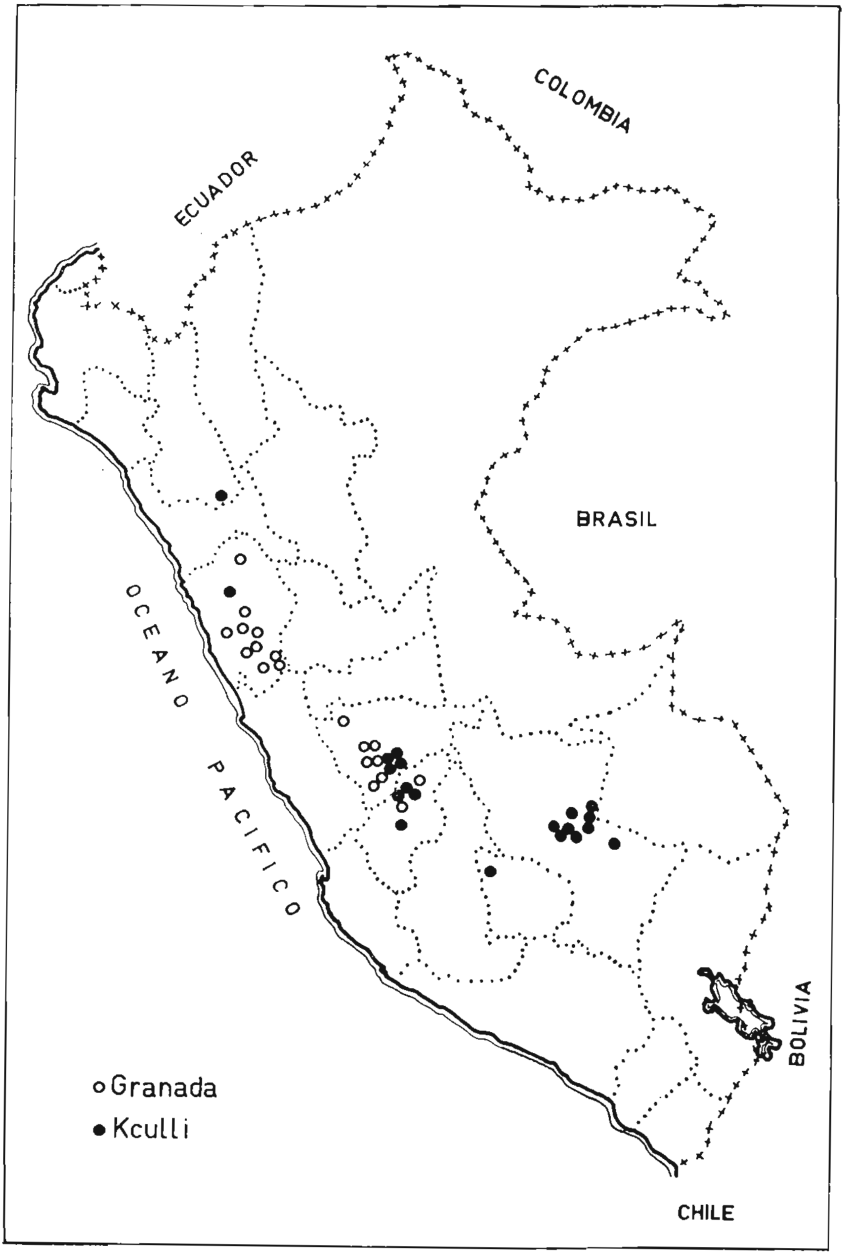


FIG. 64. Map showing the distribution of Granada and Kculli.

CONFITE PUNENO

Plants (Fig. 67). Shortest of all Peruvian races, and also probably shortest of any maize race, 56 cm. in height; earliest maturing race in the highlands, at least one month before the two previously described popcorns; non tillering, slender stalk; five to six short and narrow leaves, four to five of them above a small ear implanted on the first or second node above the ground. When the plants are hilled, so as to provide them with better drainage on clay soils, the growing ears are partly covered by soil, and thus have a relatively higher temperature around them. Leaf area very low, 863 sq. cm.; leaf pattern index high on Quadrant III, 93%; venation index low, 2.46; Helminthosporium resistance low; rust resistance intermediate; plant colors deep sun red and diluted purple; pubescence absent.

Tassel (Fig. 66). Long peduncle, 22.4 cm., a characteristic which it shares with the other popcorn races; very small tassel, shortest of all races; very short branching space, 23.5%; central spike large in proportion to total tassel length; average number of primary branches very low, 5.9; secondaries almost always absent, no tertiaries; condensation index low, 1.00.

Ears, External Characters (Fig. 65). Very short, ovoid, with no taper at the base, which is wider than in the two popcorn races described first; average number of rows 12, in an irregular kernel arrangement; slender shank; kernels small, but longer, thicker, and wider than in Confite Puntiagudo and Confite Morocho, without imbrication, non depressed, and slightly striated; endosperm flinty, poptype, yellow; purple aleurone color (*Pr*) scored by phenotypic appearance, frequently present; pericarp and cob colors as follows: colorless pericarp and white cob with a frequency of 48.7%; variegated red-variegated red (AP^{vv}), 10.3%; cherry-purple ($AP^{rr}Plr^{ch}$), 18%; light brown-light brown ($A^{b\prime}P^{rr}$) 7.78%; six other combinations with less than 3% each.

Ears, Internal Characters (Fig. 68). Average ear diameter 44.5 mm.; average cob diameter 20 mm.; average rachis diameter 13.0 mm.; estimated rachilla length very long, longest of all races in Peru, 4.2 mm.; cob/rachis index low, 1.54; glume/kernel index low, 0.30; rachilla/kernel index very high, 0.36; lower glume longer than in other Primitive Races, hairy and very soft; upper glume short, weakly pubescent, of intermediate hardness and low venation; cupules short, wide and rather deep, with medium to

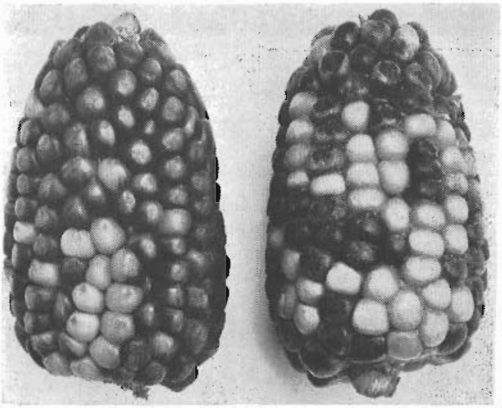


FIG. 65. Confite Puneño (Pun. 2 and 3); representative ears. Mosaic patterns on the kernels are often found in this race. It is grown in the highest altitudes, around Lake Titicaca, and has the shortest plants, among Peruvian corn races.

strong hairiness; grooves between rows of cupules are rarely ever present in this race (Cutler and Cutler, 1948); low rachis flaps; rachis induration intermediate; Tripsacum introgression at a minimum.

Distribution (Fig. 53). This race is grown at higher altitudes than any other race of maize in Peru or Bolivia, and it may be also safely stated that Confite Puneño is the race that grows at the highest altitudes in the world. Its center of dispersal is the Collao plateau around Lake Titicaca, in both Peru and Bolivia, at an altitude of 3,600-3,900 meters above sea level.

Origin and Relationships. Except for slightly larger cob and kernels, the ears of Confite Puneño are identical in form, kernel arrangement and other characteristics to the ears of Confite Iqueño, an archaeological maize race from the Coast. Since these two races, separated by a time lapse of 2,500 years are found in radically different habitats, the first at the highest limits of agriculture on the Peru-Bolvian Altiplano or Collao Plateau, and the second in the coastal valleys, it is very unlikely that either race was directly derived from the other. It may be postulated, however, that both races were derived from a common ancestor, a race which we have chosen to name Confite Chavinense. This race existed contemporaneously with Proto-Confite Morocho. It differed from the latter in having fasciated ears, with kernels irregularly arranged on the cob. Archaeological evidence for the

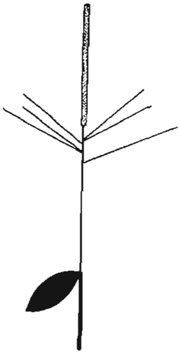


FIG. 66. Tassel diagram of Confite Puneño.

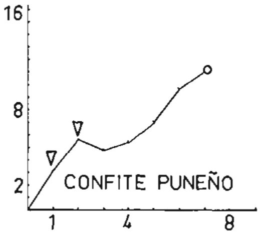


FIG. 67. Internode pattern of Confite Puneño.

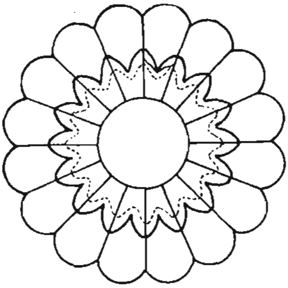


FIG. 68. Ear-cross-section diagram of Confite Puneño.

existence of Confite Chavinense comes in the form of stone replicas of ears (Fig. 41) exhibited at the Archaeological Museum of the University of Cuzco, and at the Town Library of Huanta, Ayacucho.

Although the available evidence is too limited to ascertain the approximate distribution of Confite Chavinense, the fact that four of its directly derived races in the Sierra are grown today at altitudes ranging from 2,350 to 3,600 meters, leads us to assume that it was itself distributed in the intermediate to high altitudes of the Andes. In this respect it may have been isolated from Proto-Confite Morocho, which on the basis of the lower altitudes at which its derived races are grown today, seems to us more likely to have had a lower altitude distribution than Confite Chavinense.

Confite Chavinense has now been supplanted in its original habitat by its derived, more productive races, Huayleño, Chullpi, Pisccorunto and Paro. Confite Puneño is its only derived race in

Peru which maintains the closest similarity in ear characteristics to Confite Chavinense. Some modern maize collections from the high Sierras of Tarapaca in northern Chile also still maintain the ear type of Confite Chavinense.

Confite Puneño evolved to its present racial status when the Early Farmers of the Sierra forced Confite Chavinense into the high elevations of the Collao Plateau and the southern Bolivian Andes. The ear dimensions of Confite Puneño were not changed much, and the plants maintained the earliness of their ancestral race, but became shorter in stature, under the strong natural selection pressures of their new habitats. This race also retained the deep purple plant pigmentation, ear shape and kernel characteristics which are supposed to be those of its ancestor Confite Chavinense. The basis for the assumption that Confite Chavinense had purple pigmentation is that its modern derived races at both higher and lower altitudes in the Andes have today deep anthrocyanin pigmentation in stalks and leaf sheaths, and also that purple pigmentation has been found in archaeological material of Confite Iqueño, which was one of its earliest racial derivatives on the Coast.

Confite Puneño acquired a very low ear position, which is an adaptation to high habitats, similar to that appearing in modern races that have also been carried up. Confite Puneño shows the general growth pattern of the other Primitive Races (compare Fig. 67 with Figs. 51 and 58 and with Plate VII, Appendix, of Wellhausen *et al*, 1952).

Confite Puneño is a hardy, early race which maintains its short growth habit, even when brought into more favorable environments. On account of its limited vegetative development, adapted only to the most marginal conditions for the growth of corn, and its low productivity, we do not believe that this race played any role of importance in the evolution of maize in Peru, and it should be considered as the end of one of the branches of the phylogenetic maize tree in that country.

Derivation of name. From *Confite* meaning popcorn and *Puneño,* the designation of its native habitat in the Department of Puno. It is equivalent to the race Altiplano in Cutler's (1946) classification.

ENANO

Plants. Short, average height 1.36 mm.; very early, of the same maturity class as the earliest races of the coast, Mochero and

Chaparreño; average number of leaves 12.5, rather long and narrow; venation index high, 2.92; tillers absent; plant color green; pubescence strong, and of medium hair texture; ear position medium high, 83 cm., on the eighth node above ground; with 6.2 leaves above the ear node; resistant to rust and Helminthosporium.

Ears, External Characters (Fig. 69). Very small, stubby, spheroconical in shape, with approximately 16 rows of kernels, irregularly arranged; shank very wide in proportion to the cob diameter; kernels small, flinty, dusty white in color and exhibiting extremely strong surface striations; aleurone colorless; midcob colors, 20% red, 80% brown; glume color 60% brownish, 40% colorless; lemmas, all colorless.

Ears, Internal Characters (Fig. 70). Average ear diameter small, 25.0 mm.; cob diameter 14.3 mm.; rachis diameter 7.8 mm.; pith diameter 3.8 mm.; estimated rachilla length intermediate, 2.4 mm.; cob/rachis index large, 1.83; glume/kernel index very large, 0.52; rachilla/kernel index highest of all the races of the Peruvian area, 0.38; lower glume very short, moderately pubescent, rather soft; upper glume very short, with weak pubescence, soft, strongly veined; cupules very short, narrow, and shallow, with rather strong hairiness; height of rachis flaps intermediate; rachis induration high; moderate to high expression of tripsacoid characters.

Distribution (Fig. 53). Enano has been collected in Peru in the jungle areas of the Department of Madre de Dios, particularly along the Tambopata, which is one of the affluents of the Madre de Dios river system. The elevation of the collection site was 270

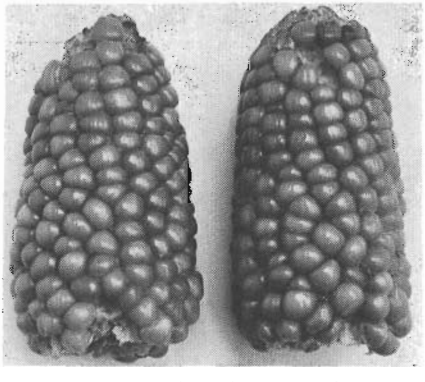


FIG. 69. Enano (M. de Dios 3); representative ears.

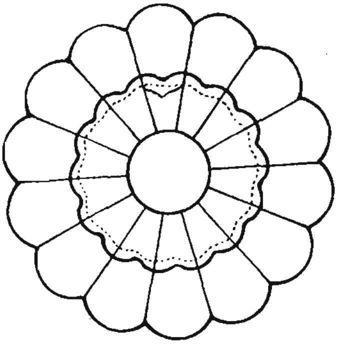


FIG. 70. Ear-cross-section diagram of Enano.

meters. It appears, however, that the present geographical center of the distribution of this race lies further east, in the area between the Acre and Madre de Dios rivers in Bolivia.

Origin and relationships. On the basis of external ear morphology Enano resembles Confite Puneño more than any other race, particularly in ear shape and dimensions, and in type and size of kernels. It appears to be, however, more tripsacoid than the latter race. Enano also resembles Piricinco in ear morphology, although it lacks the length and the bizarre kernel colors of the latter race. These morphological associations make us suspect that Enano is a derivative of Confite Chavinense, (which is also ancestral to Confite Puneño) introgressed by *Tripsacum australe* and established in the Acre-Madre de Dios-Beni Basins. Enano may then have hybridized later with Rabo de Zorro to form Piricinco (Coroico) with which race it is sympatric in the Departments of Pando in Bolivia and Madre de Dios in Peru.

Derivation of Name. Priority is accepted for the designation of Enano given by Ramirez *et al* (1960), considering furthermore that this race appears to be more widely distributed in Bolivia. The common name of the three collections available from Peru is Tambopateño.

ANCIENTLY DERIVED RACES

The races included in this group will be presented in what is believed to be an approximate chronological sequence of their times of origin. They are both early racial selections from hybrid populations resulting from the intercrossing that took place among the primitive popcorns, as well as their immediate second *step* derivatives. Some of the latter resulted from the hybridization of an early racial derivative with a primitive race, while some of the races described at the end of this section had two early derivatives as ancestors.

The common feature of all these races is that they came into existence in the pre-Columbian Epoch.

HUAYLENO

Plants (Fig. 73). Very short, approximately 118 centimeters high, taking an average of 143 days from planting to mid-silking when grown at 3,200 meters above sea level (Cuzco and Junin), and 135 days to mid-silking when grown at 2,800 meters (Urubamba). One typical collection of this race grown in Ayacucho at 2,300 meters took 87 days to midsilking. Average number of leaves 10.7; leaves intermediate in length and width; venation index high, 3.2; leaf area low, 5,070 sq. cm.; leaf pattern index 94% in Quadrant I; 5.3 leaves above the ear; ear located at an average of 87 cm. above ground; no tillers; plant color mostly dilute sun red; pubescence absent; highly susceptible to rust, susceptible to leaf blight.

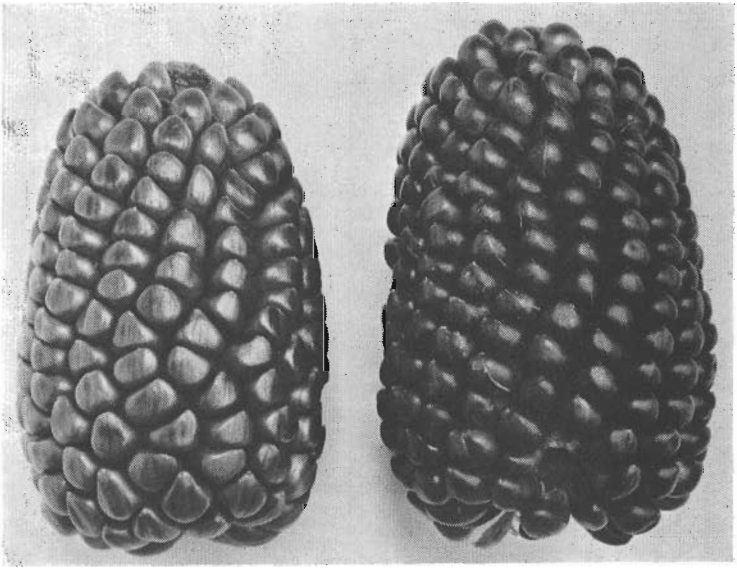


FIG. 71. Huayleño, representative ears. A great variation of pericarp and cob colors is exhibited by this race, brown and reds being, however, the most frequent colors.

Cytological Characters. Small to medium knob intercalary on 7L with a frequency of 63%; small to medium knob intercalary on 9L, 43%; small knob intercalary on 6L, 14%. Most frequent number of knobs per cell, 1. Supernumerary chromosomes often present; range of B-chromosome numbers, 0 to 2.

Tassels (Fig. 72). Long peduncle, 195 cm.; large branching space in proportion to tassel length, 43.5%; total tassel length very short, 19 cm., larger only than Confite Puneño; central tassel spike shortest of all Peruvian races; tassel branches very short; number of primary branches intermediate, secondary branches low, tertiary branches none; condensation index low, 1.01.

Ears, External Characters (Fig. 71). Short, wide in proportion to their length, ovoid tending to conical; strong taper at tip, slight taper at the base; irregular arrangement of kernels, with no definite rowing pattern; very short and slender shank, with low number of shank nodes; low number of husk leaves, average 6.5; kernels medium sized with slight or no imbrication; flat surfaced cap, kernel depression none; kernel striation lacking; endosperm white, floury, soft; aleurone color rarely purple, mostly colorless; pericarp and cob colors are strikingly variable; they carry all the range of *A* and *P* allele combinations: colorless pericarp-white cob, 18.7%; brown-brown $(A^{b\prime}P^{rr})$ 29.7%; red-red, (AP^{rr}), 11%; brown red- brown red $(A^{b\prime}P^{rr})$, 5.6%; red white cap-red (AP^{cr}), 5.1%; colorless-red (AP^{wr}), 4.9%; twenty other combinations with lower frequencies.

Ears, Internal Characters (Fig. 74). Average ear diameter 42 mm.; average cob diameter 21 mm.; average rachis diameter 11.4 mm.; estimated rachilla length intermediate, 2.3 mm.; cob/rachis index high, 1.84; glume/kernel index intermediate, 0.37; pith diameter intermediate; lower glume medium-short, strongly pubescent, texture of glume tissue hard; upper glume with medium pubescence, hard tissues, and weak to intermediate venation; cupules intermediate in length, width and thickness, strongly pubescent; with low rachis flap height; midcob color red in 30% of ears examined; color in glumes (brown) in 80% of ears, and 70% color in lemmas; rachis tissue soft and spongy; Tripsacum introgression none to slight.

Distribution (Fig. 75). This race has a definite center of distribution in the Callejon de Huaylas, a narrow valley between two parallel ranges of the Cordillera Occidental, the Cordillera

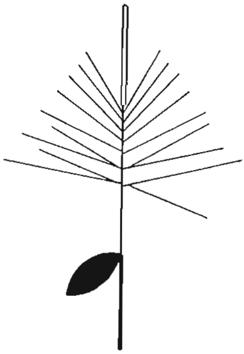


FIG. 72. Tassel diagram of Huayleño.

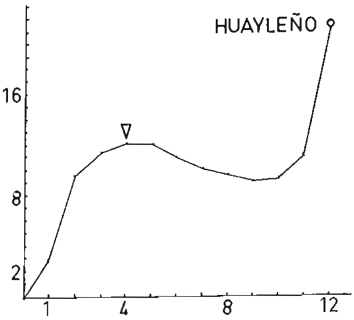


FIG. 73. Internode pattern of Huayleño.

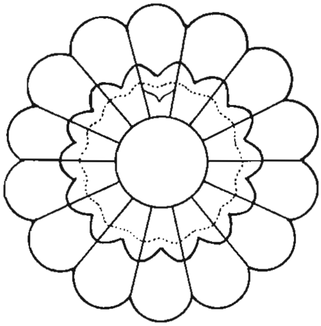


FIG. 74. Ear-cross-section diagram of Huayleño.

Blanca and the Cordillera Negra. The Santa river flows northward between these ranges and eventually curves westward, making its way through a narrow canyon, to form later the water rich Santa valley of the Central Coast.

The race Huayleño is found in its purest form in the Callejon de Huaylas, in the Province of Huaylas. It also occurs in several other localities within the Department of Ancash, and collections corresponding to the general racial type have been made further south in the Department of Lima (locality of Canta) and in Ayacucho and Huancavelica.

Huayleño, is found at altitudes of between 2,500 and 3,600 meters, with collections evenly divided from localities below and above 3,000 meters.

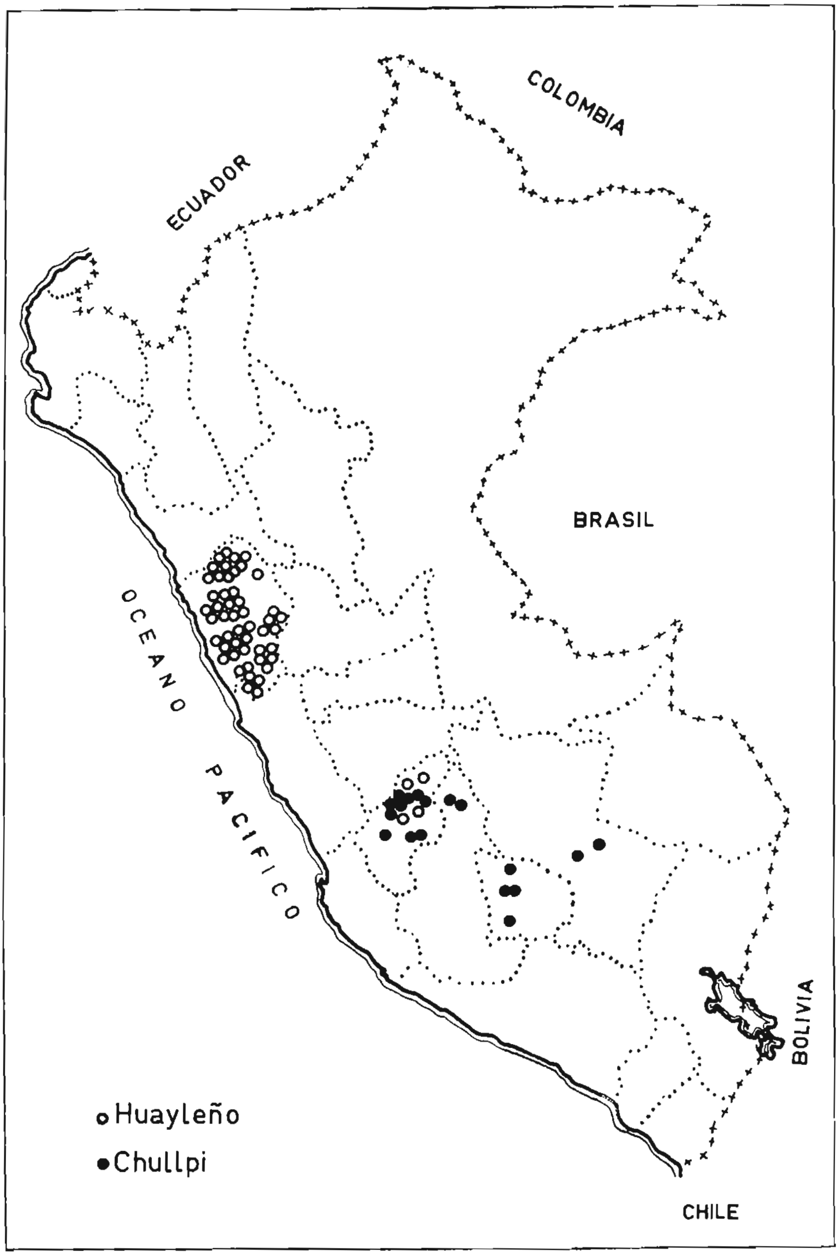


FIG. 75. Map showing the distribution of Huayleño and Chullpi.

Origin and Relationships. It appears likely that the prehistoric popcorn Confite Chavinense was either domesticated in the Callejon de Huaylas or neighboring areas or was introduced there in a cultivated form very early. This area is today a world center for brown and red-brown pericarp colors, found particularly in the races Huayleño and Ancashino, colors which, since they were present in the earliest archaeological maize in Peru, may have been those of Confite Chavinense and even of wild corn.

Huayleño is a direct floury maize derivative of Confite Chavinense, produced by selection in the Department of Ancash, the same general region where we are assuming Confite Chavinense preceded it. Gene flow from other primitive non-tripsacoid races of Andean maize may have provided the original variability on which selection could operate effectively to lead to modern Huayleño.

Huayleño corn is highly prized for preparing a roasted corn food called *kcancha,* made by toasting the shelled kernels in a clay pot over a direct fire, and eating them semi-cracked, softened, and salted, as a substitute for bread. Huayleño corn with a brown pericarp color is supposed to be sweeter, more tender, and a better roaster than other corn types.

The method of preparing Huayleño for food could have been directly derived from popping, the way in which Confite Chavinense, the ancestor of Huayleño, was undoubtedly prepared. As Confite Chavinense acquired floury kernels it ceased to pop when heated, and a more productive race, which could be used for food by roasting the kernels in the same manner that the ancestor was popped, came into being.

Huayleño is either a direct ancestor of Ancashino or both races evolved simultaneously from the hybridization of earlier Andean popcorn races (see discussion under Ancashino). Huayleño is also related through Confite Iqueño, the early coastal derivative of Confite Chavinense, to the coastal races Mochero, Chaparreño and their later derivatives (Fig. 234).

Derivation of name. Huayleño, as a racial name, comes from the word Huaylas that designates the province and town where this race is prevalent. Another name it also receives is Terciopelo (velvet in Spanish), probably referring to the softness of its kernels.

CHULLPI

Plants (Fig. 78). Tall, the pure typical Chullpi of the southern Andes attaining greater heights than other Sierra races; late maturing, 144 days to mid-silking as an overall average at a variable altitude range; medium long, and narrow leaves, intermediate in number, leaf area low, 3,900 sq. cm.; venation index high; ear located at a short distance above center of plant, on a medium to wide stalk, which tillers only occasionally; usually has a tendency to having two ears per plant; plant color deep sun-red; pilosity absent; low to intermediate resistance to corn rust, and highly susceptible to Helminthosporium; internode diagram unique among Peruvian races, having a somewhat close counterpart only in certain collections of Confite Puneño; it shows a continuously ascending pattern (Fig. 78).

Cytological Characteristics. Most of the collections studied (55%) were found to have one tiny knob subterminal on the

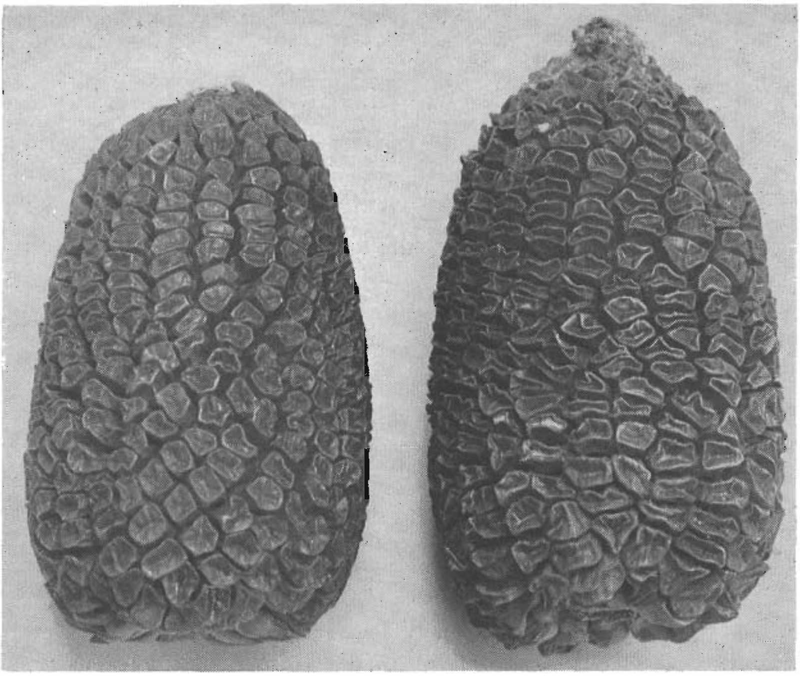


FIG. 76. Chullpi (Cuz. 75); representative ears. This race is likely to be the ancestor of all the sweet corn races. Its ears are short, round, and fasciated, with an irregular kernel arrangement.

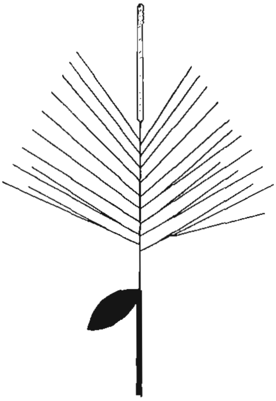


FIG. 77. Tassel diagram of Chullpi.

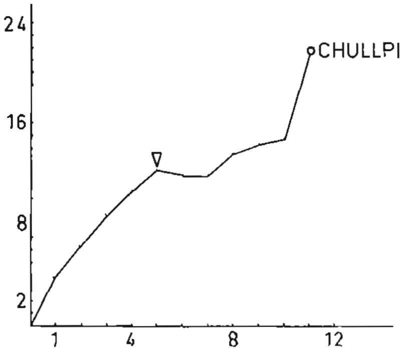


FIG. 78. Internode pattern of Chullpi.

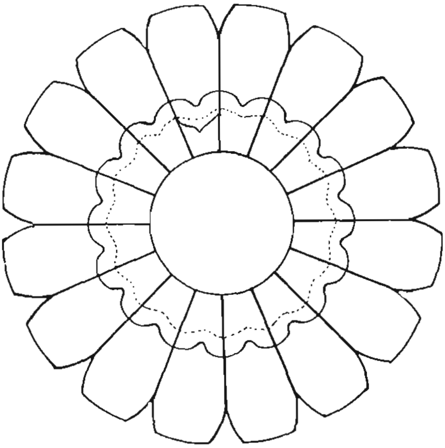


FIG. 79. Ear-cross-section diagram of Chullpi.

long arm of chromosome 7. Of this 55% some 40% had one small additional knob on the long arm of chromosome 6. About half of the plants studied were knobless. No B-type chromosomes were found.

Tassels (Fig. 77). Long peduncle; medium long tassel, with many intermediate long primary, few secondary, and no tertiary branches, occupying a branching space of half of the tassel; condensation index low, 1.0.

Ears, External Characters (Fig. 76). Short, very wide, ovoid (hand grenade) shaped, frequently fasciated; rowing is not distinct, the kernels appear to be irregularly arranged, they would approximate 18 rows if rearranged; shank intermediate in length, with intermediate number of nodes and husks, slender; kernels extremely long, 16.5 mm., relatively wide and of intermediate thickness, sugary (*su* gene), with a depression on the cap, beaked, and without striations; endosperm color in typical Chullpi yellow; aleurone colorless; pericarp and cob color as follows: colorless pericarp-white cob 58.6%; brown-brown ($A^{b'}P^{rr}$) 13.3%, colorless-red (AP^{wr}) 9.3%, variegated red-variegated red 5.3%, mosaic red-mosaic red 5.3%, three other combinations with less than 3%; a staminate tip is frequently present.

Ears, Internal Characters (Fig. 79). Average ear diameter 58.0 mm.; average cob diameter 29.2 mm.; average rachis diameter 18.2 mm.; pith diameter large, 9.2 mm.; estimated rachilla length very long, 3.4 mm.; cob/rachis index intermediate, 1.60; glume/kernel index low, 0.33; rachilla/kernel index medium, 0.21; lower glume of medium length, more pubescence than average, rather hard; upper glume medium long, slightly pubescent, medium-hard texture, strongly veined; cupules long, narrow, and very shallow, in fact, more so than in any other Peruvian corn race and very weakly pubescent (second lowest of all Peruvian races); height of rachis flaps greater than any other Peruvian race; rachis tissue induration medium; midcob color present in one third of ears examined, no color in either glumes or lemmas; Tripsacum introgression not evident.

Distribution (Fig. 75). Chullpi is widely distributed in the Sierra of Peru. Its center of dispersal is located in the Departments of Cuzco, Apurimac, Huancavelica, and Ayacucho, where it is found in its purest form. As it was an ancient race and a highly relished type of corn, Inca conquests extended its cultivation to the farthest boundaries of their Empire, which accounts for its being found in the Andean zone of northern Chile, in Bolivia, northern Argentina, and in Colombia.

In the Peruvian Andes it is grown at altitudes ranging from 2,400 to 3,400 meters.

Origin and Relationships. The ears of Chullpi maintain to a very large extent the primitive conditions of ear fasciation, ovoid-shape, and irregular kernel disposition found in Confite Chavinense, one of the races from which it originated (Fig. 80).

Modern Chullpi is a sweet corn derivative of the primitive

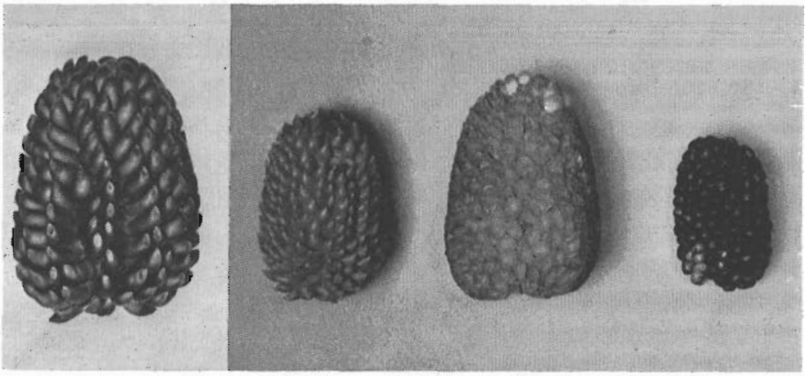


FIG. 80. Races related through common descent or influence from Confite Chavinense. From left to right: Paro, Fasciated Confite Puntiagudo, Chullpi, Confite Puneño.

Proto-Chullpi, which had smaller ears and floury kernels, and which originated in turn from selection of fasciated-eared segregates of hybrid populations between fasciated-eared Confite Chavinense and beaked-kernelled Confite Morocho.

Ceramic representations of what is thought to be a Proto-Chullpi form, at the University of Cuzco Archaeological Museum (Fig. 39) and in the Huanta Town Library Collection in Peru, show positively that the racial characteristics of external ear morphology of Chullpi have undergone little change for at least 1,000 years.

Chullpi carries the sugary allele *su* on choromosome 4 (Cutler, 1946; Grobman, 1958a) just as does North American sweet corn. It also probably carries some additional modifiers, which increase the shrunkenness of its kernels to a phenotype similar to that produced by the gene *sh*.

It is unlikely that Chullpi existed contemporaneously with the primitive popcorns in the Incipient Agricultural Epoch. The sugary gene conditions a sub-optimal endosperm phenotype in regard to total endosperm development, and storage of carbohydrates (Mangelsdorf, 1926), increases susceptibility to soil fungi, lowers the ability of corn seed to undergo prolonged storage, and diminishes germination potential. Only in highland locations, where low temperatures of storage would reduce spoilage of seed, and after irrigation-agriculture had developed, could a sweet corn race have been successfully maintained for the first time.

Chullpi is found in its purest form in the south central Andes, where we think it originated. In collections of sweet corn from locations successively farther north or south of its central area of dispersion, the interesting observation may be made that the globose type of the Chullpi ear tends to change gradually to a cylindrical form. This tendency is more pronounced at northern locations than at the southern ones. The "Dulce" ear type of Chullpi corn from the northern Sierra (Department of Cajamarca), is very similar in appearance to the cylindrical ears of the Colombian Dulce race described by Roberts *et al* (1957), which has only slightly irregular rowing.

The sweet corn of Mexico, Maize Dulce, classified as an "Exotic Race" (Wellhausen *et al,* 1952) is probably a local derivative of Chullpi introduced into Mexico presumably shortly before the Spanish Conquest, perhaps in its "Dulce" form prevalent in northern Peru and Colombia.

It is evident that Chullpi was brought down to the coast of Peru before and during the Tiahuanaco intrusion. Although it never was established there permanently, it contributed genes to the corn that was grown at that time on the coast, a floury derivative of Confite Iqueño. The resulting race, Chaparreño, although short and globular eared, profited from the long ("deep") kernel yield component of Chullpi and became established about 600-800 years ago in the coastal area between the valley of Tambo (Arequipa) and the central valleys of the present Department of Lima.

As will be discussed later, Paro is a Sierra race very closely related to Chullpi (see Fig. 76). We are not certain as to whether Paro and Chullpi developed independently from a common ancestor or whether one preceded the other. All available evidence points to a great antiquity of both races.

Chullpi is a good potential source of heterosis for yield crosses with other Peruvian highland material. Unpublished data obtained in the Sierra maize breeding projects point to Chullpi as one of the races giving high F_1 yields in intervarietal crosses, particularly with varieties coming from races which have Confite Morocho as an ancestor. This high combining ability could presumably be due to genetic diversity tracing back to evolutionary divergence from primitive wild races of maize, after domestication, resulting in multiple general heterozygous and heterotic loci in the F_1 hybrids of Chullpi with cylindrical-ear races. The multiple row condition (ear fasciation), long kernels and the two-ear character are important yield components contributed by Chullpi to its hybrids.

In spite of being a sweet corn, Chullpi is not consumed green on the cob, but the shelled kernels are roasted and eaten dry as *kcancha*. In this form it is one of the types of corn most relished by the Indians.

The fact that Chullpi, Huayleño and Paro, postulated as descending from a common popcorn ancestor Confite Chavinense, are all consumed as *kcancha,* the closest form of utilization to popping, is suggestive of their racial relationship, and possibly of the parallel development of these races under selection for a common form of utilization.

Derivation of Name. The word *Chullpi* is used in the Quechua language to designate specifically a sweet corn. It is the name assigned by the Sierra Indians to all corn that exhibits the presence of sugary kernels. This race is also commonly referred to as Chuspillo.

GRANADA

Plants (Fig. 83). Short, average height 136 cm.; early, taking 140 days to mid-silking at 3,200 m. above sea level in Cuzco, and 143 days at the same altitude in the Mantaro valley; average number of leaves 10.4, with 5.4 leaves above the ear-bearing node; leaves short and narrow; venation index medium-large,

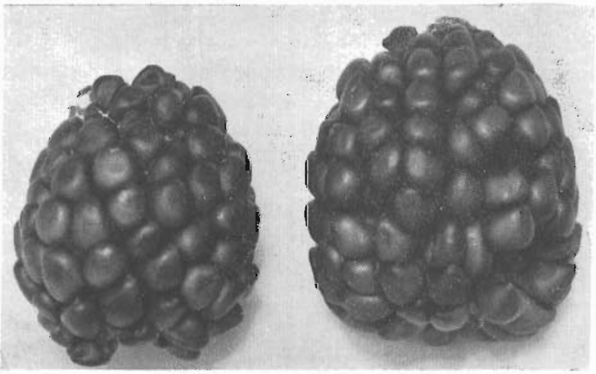


FIG. 81. Granada; representative ears.

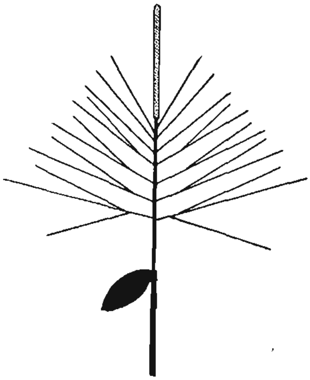


FIG. 82. Tassel diagram of Granada.

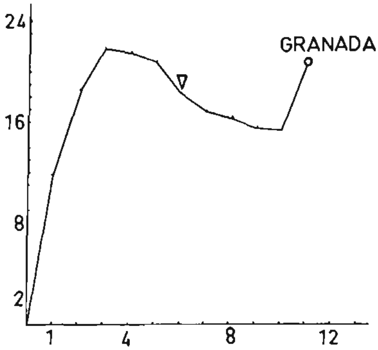


FIG. 83. Internode pattern of Granada.

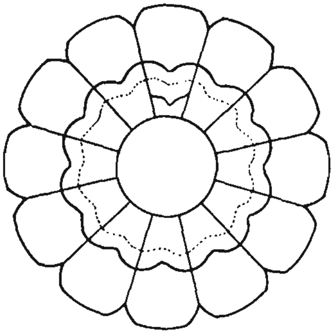


FIG. 84. Ear-cross-section diagram of Granada.

3.1; stalk of moderate thickness, with neither tillers nor aerial prop roots; ear placed low on the stalk at about 53 cm. from the ground; plant color sun red or very often purple; medium hairiness; intermediate resistance to rust and Helminthosporium.

Cytological Characteristics. One small knob subterminal on chromosome 7 long arm with a frequency of 87.5%; one small knob subterminal on 6L, with a frequency of 12.5%; totally knobless plants with a frequency of 12.5%; B-chromosomes range in number from one to two and were present in 37.5% of the plants examined.

Tassels (Fig. 82). Peduncle of medium length; tassel short, with relatively short total branching space, 13.6 cm., but large in proportion to tassel length, 49.1%; branches intermediate in length; intermediate number of primary and secondary, and no tertiary branches; condensation index low, 1.02.

Ears, External Characters (Fig. 81). Short, globose, average length 8.58 cm., with an average number of 12 rows, and often with an irregular kernel arrangement; shank short and slender, with low number of nodes; low number of husks, 8.0; kernels rather large in length, width and thickness, with slight surface striation; endosperm, white, floury, and soft; midcob color purple in ⅔ of ears examined; glumes purple in ⅓ of ears, brown in ⅓; and colorless in ⅓; lemmas red in ⅓ of ears; pericarp and cob color alleles, as follows: colorless-white 34.7%; brown-brown ($A^{b\prime}P^{rr}$) 14.8%; colorless-red (AP^{wr}) 9.2%; variegated red-variegated red (AP^{vv}) 7.7 %; red-red (AP^{rr}) 7.1%; red white cap-red (AP^{cr}) 6.1%; red white cap-white (AP^{cw}) 4.6%, and twelve other combinations (Table 6A) ranging in frequency from 0.5 to 2.5 per. cent.

Ears, Internal Characters (Fig. 84). Average ear diameter 42.6 mm.; cob diameter 23.0 mm.; rachis diameter 13.2 mm.; pith diameter 5.2 mm.; estimated rachilla length intermediate, 1.6 mm.; cob/rachis index intermediate, 1.74%, glume/kernel index low, 0.37, rachilla/kernel index low, 0.12; lower glume medium long, strongly pubescent, rather hard; upper glume of medium length, slight hairiness; very soft, and very strongly veined; cupules short, and intermediate in width and in depth, with an intermediate degree of hairiness, height of rachis flaps low; rachis induration very weak, among lowest of all Peruvian races; tripsacoid characters absent.

Distribution (Fig. 64). Granada is grown at the higher altitudes, above 3,000 meters, in the central Andes, from Cuzco to Ancash. The largest number of collections of this race come from Ancash, Junin and Huancavelica.

Origin and Relationships. Granada is one of the least distinct among all Peruvian races in that it does not possess striking morphological ear characters and presents a markedly high degree of phenotypic variability. It can, nevertheless, be singled out on account of its small, round ears, with very few large kernels. The only other race with short ears and a small number of large pointed kernels is Kculli. These two races are obviously closely related, Kculli being the ancestral one. Many ear and plant characteristics including a high frequency of purple colored plants are shared by both races.

It may well be that one of the early derivatives of Confite Chavinense, very likely Huayleño, hybridized with Kculli, giving rise to the new race Granada. This hypothesis is supported by: (a) the similarity of chromosome-knob constitution of the three races, (b) the high frequency of brown pericarp and cob colors in Granada, which can be traced back to the Huayleño parent, (c) the adaptation of all three races to very high altitudes, (d) the sympatric distribution of Granada with the other two races, and (e) the intermediate nature of Granada between the corresponding average values of Huayleño and Kculli, in respect to several biometrical characters (Table 10). In fact, Huayleño is intermediate or does not differ much from one or the other parent in 21 out of 36 characters shown in Table 10. In eleven other characters it exceeds either parent. This discrepancy could be explained by heterotic or cumulative gene action in the hybrid race.

It is likely that some of the collections classified as Granada may have had Huancavelicano, a derivative of Kculli, as a putative parent instead of the latter. That Huancavelicano is not the main ancestor of Granada, however, may be easily demonstrated by its lower frequency of the *Pl* gene, too low to have given off the large frequency of this gene in Granada, and by the different ear construction, absence of definite rowing, and irregular kernel arrangement of most collections of Granada.

Derivation of Name. In the Apurimac and Cuzco corn growing areas, the name *Nueva Granada* is generally applied to a type of corn which exhibits dilute anthocyanin staining at the base of the kernels, produced probably by the pigment being washed off from the cob tissue. Most of the ears of the race described here, collected in these areas, would be classified by Indian farmers as *Nueva Granada.* This name has originated in the subtropical valley of La Convencion, Cuzco, where it is applied to a late, low altitude, highly tripsacoid race, Chuncho, whenever it has kernels with superficial purple staining at their base (see discussion under the race Chuncho for origin of name Nueva Granada).

To make the name restrictive, Granada was chosen as a racial denomination for this highland race; it also emphasizes the characteristic hand grenade shape of its ears.

TABLE 10. Comparison of Granada with its Postulated Parental Races Kculli and Huayleño.

	Kculli	*Granada*	*Huayleño*
Plant Characters.			
Height of Plant (cm)	92	136	118
Ear Height (cm)	29	53	87
Number of Leaves	9.5	10.4	10.7
Leaves above the Ear	5.3	5.4	5.3
Length of Leaves (cm)	58.0	66.6	61.6
Width of Leaves (cm)	7.4	6.9	7.7
Venation Index	3.31	3.10	3.20
Stalk Diameter (mm)	19.0	24.0	20.1
Days to Midsilk	137	140	138
Tassel Characters.			
Tassel Length (cm)	27.2	27.7	19.1
Length of Branching Sp. (cm)	8.8	13.6	8.2
Percent of Branching Sp. (cm)	22.1	49.1	43.5
Number of Primary Branches	10.3	15.2	14.9
Number of Secondary Branches	2.3	9.5	3.3
Number of Tertiary Branches	0	0	0
Condensation Index	1.00	1.02	1.01
Length of Peduncle (cm)	19.6	18.2	19.5
Ear External Characters.			
Length of Ear (cm)	9.23	8.58	11.63
Diameter of Ear (cm)	4.71	5.16	4.93
Row Number	12.00	Irreg.	8.60
Shank Length (cm)	6.14	6.75	4.82
Shank Diameter (cm)	0.88	1.03	1.00
Kernel Length (mm)	13.78	13.10	13.00
Kernel Width (mm)	10.27	9.70	7.90
Kernel Thickness (mm)	6.01	6.00	5.30
Ear Internal Characters.			
Cob Diameter (mm)	21.3	23.0	21.0
Rachis Diameter (mm)	15.2	13.2	11.4
Rachilla Length (mm)	0.8	1.6	2.3
Cob/rachis Index	1.40	1.74	1.84
Glume/kernel Index	0.20	0.37	0.37
Rachilla/kernel Index	0.05	0.12	0.18
Cupule Length (mm)	1.4	1.7	2.1
Cupule Width (mm)	8.1	6.9	5.3
Cupule Depth (mm)	2.4	1.4	1.6
Cupule Pubescence	1.10	1.30	2.20
Upper Glume Length (mm)	2.8	4.0	4.2
Lower Glume Length (mm)	3.1	5.7	5.1
Height Rachis Flaps	1.66	1.30	0.95
Rachis Induration	3.00	2.70	3.20

PARO

Plants (Fig. 87). Short, average height 1.24 cm. intermediate maturity, 144 days to mid-silking at 3,200 meters above sea level; low average number of leaves 9.3, 4.5 of which are above the ear node; leaf area intermediate to low, 4.261 sq. cm., leaf length and leaf width intermediate, venation index large, 3.46; stalk diameter intermediate, without visible prop roots; lacking tillers; plant color sun red; pubescence absent; intermediate susceptibility to both Helminthosporium leaf blight and leaf rust.

Cytological Characteristics. One small knob subterminal on chromosome 7 long arm with a frequency of 50%. Totally knobless chromosome complements appear with a frequency of 50%. Supernumerary chromosomes range in number from one to three per nucleus, and are present with a frequency of 37.5%.

Tassels (Fig. 86). Peduncle very long; tassel length large, 33.0 cm., branching space intermediate, 12.0 cm., and 36.4% of the whole tassel length; length of branches intermediate; number of

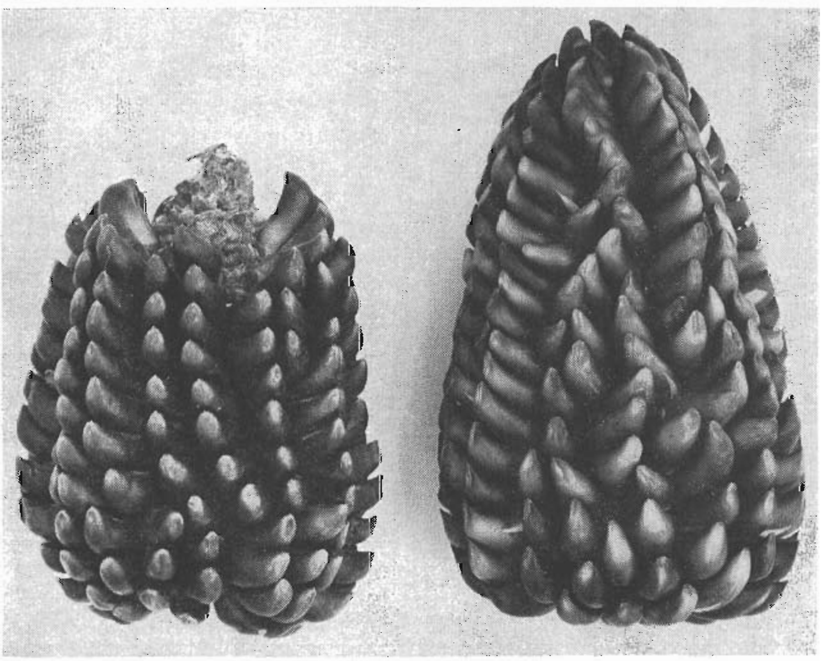


FIG. 85. Paro (Apuc. 33); representative ears. Note the spreading habit of the spikelets.

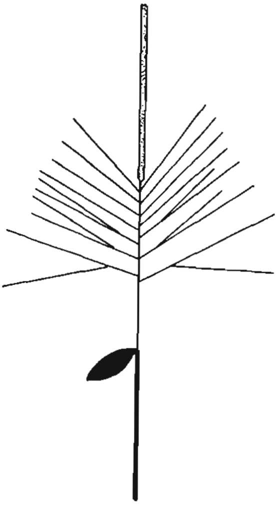


FIG. 86. Tassel diagram of Paro.

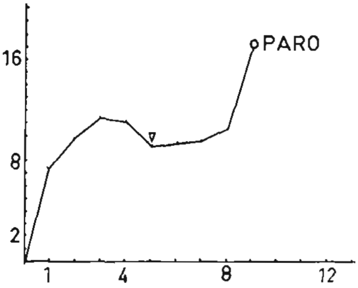


FIG. 87. Internode pattern of Paro.

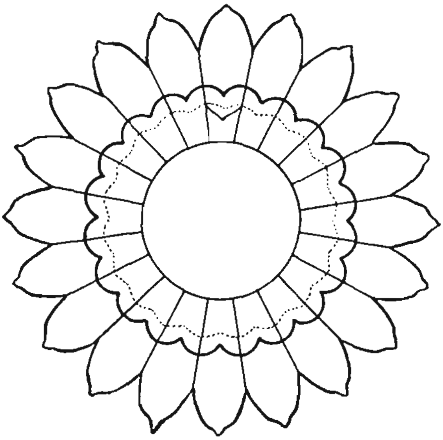


FIG. 88. Ear-cross-section diagram of Paro.

primary and secondary branches intermediate; no tertiary branches, condensation index low, 1.03.

Ears, External Characters (Fig. 85). Short, average length 11.5 cm.; globose, tapering to the tip; number of rows 14 to 18, somewhat irregularly arranged in some ears; shank length intermediate, diameter and number of nodes small; number of husk leaves intermediate, 8.05; kernels very long, with small width and intermediate thickness, terminating in a pronounced beak, and exhibiting a high degree of imbrication; spikelets in many ears

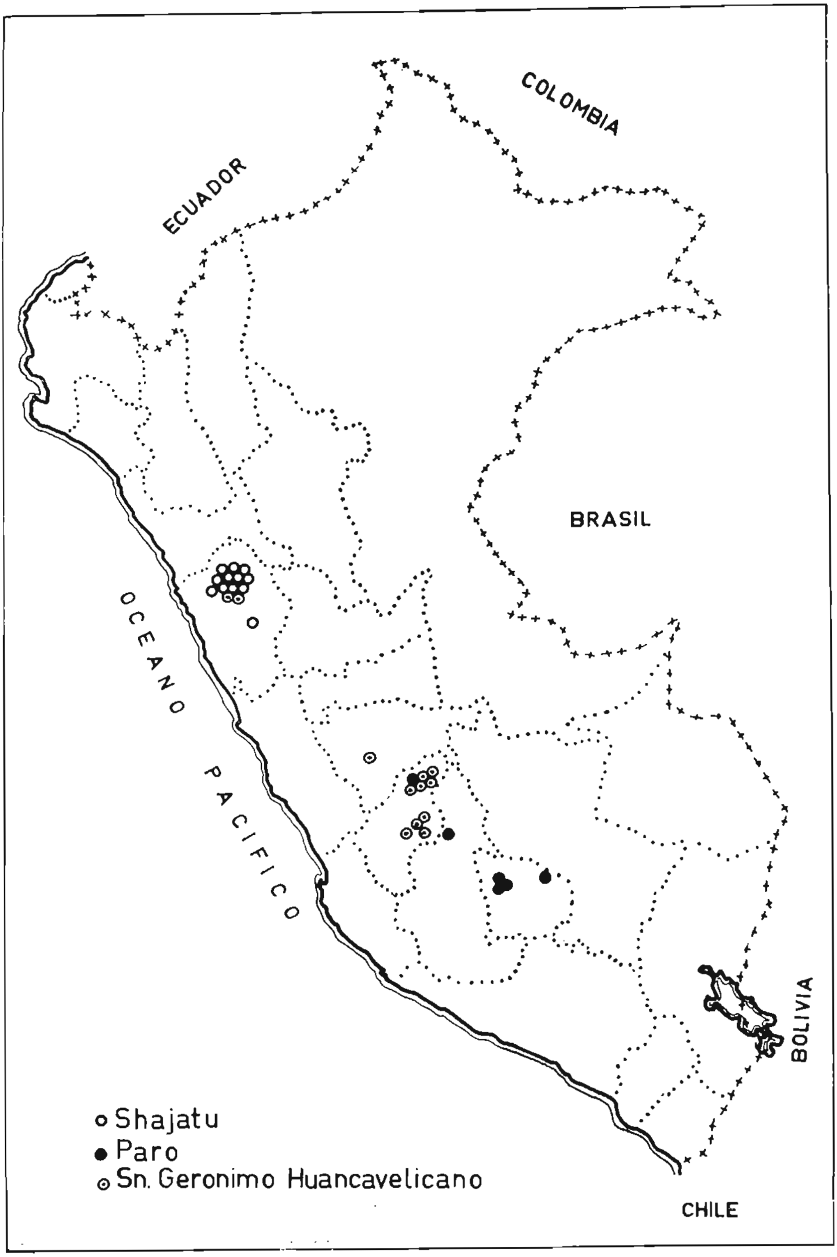


FIG. 89. Map showing the distribution of Paro, Shajatu, and San Geronimo Huancavelicano.

show a spreading habit, as extreme as found in any race; kernels very loosely attached to the cob, and shell off easily; surface striation absent, indicating in this race low husk compression; endosperm floury, fairly soft, white; midcob color absent in 80% of ears; glumes and lemmas colored red; pericarp and cob color combinations: colorless-white 53.5%, brown-brown ($A^{b'}P^{rr}$) 7.1%, colorless-red (AP^{wr}) 17.8%, variegated red-variegated red (AP^{vv}) 5.4% and nine other allelic combinations, each with a frequency of 1.8% (Table 6A).

Ears, Internal Characters (Fig. 88). Average ear diameter 43.3 mm., among widest of all races, average cob diameter 29.4 mm., average rachis diameter 20.1 mm., pith diameter 10.3 mm.; estimated rachilla length long, 3.8 mm.; cob/rachis index low, 1.46; glume/kernel index low, 0.31; rachilla/kernel index intermediate, 0.25; lower glume length intermediate, weakly pubescent, very soft; upper glume medium-long, slightly pubescent, medium texture, strongly veined; cupule length short, intermediate in width and in depth, height of rachis flaps large; rachis induration intermediate.

Distribution (Fig. 89). Paro is limited in its distribution to the central-south Andean region with its largest concentration in the Department of Apurimac, and diffusing from there to Ayacucho and Huancavelica. It is cultivated at altitudes between 2,600 and 3,300 meters above sea level.

Origin and Relationships. The hybridization of Chullpi with Confite Puntiagudo could very well have been the starting point for the origin of Paro. We do not, however, wish to disregard altogether the alternative hypothesis that Chullpi and Paro are sister races, branching off from some common ancestor as the result of differential selection. Since the former hypothesis seems more plausible we shall present the evidence favoring it. This race was selected as a floury counterpart of Chullpi, very similar in its ear type, and conforming also to the specialized use of the parent race as a parching or toasting corn.

Paro is obviously intermediate in many characteristics between its putative parents, as can be seen in external ear morphology (Fig. 85), ear-cross-section diagrams, internode pattern diagrams, and tassel diagrams.

Cytologically, Paro shares with its putative parents the same chromosome knob situation, that is, two small subterminal knobs, one on chromosome 6 long arm, and one on chromosome 7 long arm. Confite Puntiagudo has plants which have either one or both of these knob positions simultaneously plus others that may have arisen later, on other chromosomes.

Paro also resembles Confite Morocho in many characters, particularly those referring to tassel measurements. In spite of these similarities, Confite Morocho is not postulated as one of the ancestors of Paro, since an examination of these same characteristics discloses considerably closer similarity with the measurements of Confite Puntiagudo, the other postulated parent of Paro. Also, a higher number of more stable characters, such as internal ear measurements, agree better with Confite Puntiagudo than with Confite Morocho. Particularly important is the increase in rachis diameter of Paro, which could have obtained genes for wider cob more likely from Confite Puntiagudo than from Confite Morocho.

Once again, we find here a hybrid race, in this case Paro, whose ear type has been strongly selected towards the most productive parent, while quantitative homologies have not kept up with tassel dimensions which are intermediate between both parents. This is contrary to the expectations based on Anderson's (1944) postulated quantitative ear-tassel homologies. The breakage of quantitative homology is probably due to recombination and differential recurrent selection; natural selection for tassel type; and artificial selection for ear type, operating simultaneously and independently of each other.

This situation would require an explanation based on the existence of certain "switch" genes controlling the developmental homologies of ear and tassel. Alleles of these genes would be susceptible of being selected for or against, thereby maintaining or throwing off ear-tassel homologies in hybrid population segregates.

Derivation of Name. From the Quechua word applied to the majority of collections of this race. *Paro* or *Paru* in a strict sense is used to designate a white corn, as is *Yuraq* (Mejia Xesspe, 1931), but like many Quechua terms applied to plants, it has experienced localization of meaning in some areas. Its use as a racial name is justifiable on the basis of the wide application of the term to the race we are describing in the areas of Apurimac and Andahuaylas.

MOROCHO

Plants (Fig. 92). Short, average height 154 cm. in native habitat; intermediate maturity, 104 days to silking at 2,300 meters, 149 days at 2,800, and 150 days at 3,200 meters above sea level; average number of leaves low; leaves short and rather narrow, venation index very high, 3.58; leaf area intermediate, 5,000 sq. cm.; leaf pattern index 100% Quadrant II; plant color mostly dilute sun-red; pubescence lacking; intermediate resistance to rust and leaf blight.

Cytological Characteristics. Chromosome knobs none to two. A frequency of presence of 58% was found for a small knob on the long arm of chromosome 7, and 16% for a small to medium knob on the long arm of chromosome 4, both being subterminal. The frequency of the joint presence of both knobs is 22%; and the frequency of absolute absence of both knobs is 44%. The variation in number of B-chromosomes goes from 0 to 4, with 0 the most frequent class. Presence of at least one B-chromosome has a frequency of 33%; most common frequency is two B-chromosomes per nucleus.

Tassels (Fig. 91). Long tassel peduncle; very short tassel length; short branching space, 7.8 cm., relative to tassel length 31.5%; very few branches, 83% being primary and the rest secondary; condensation of the tassel low, 1.00.

Ears, External Characters (Fig. 90). Intermediate length, cylindro-conical, with a rather wide base and tapering towards the tip; narrow, average number of rows 10.7, spirally or irregularly arranged kernels; short, slender shank; number of husk leaves low, 6.3; kernels medium in length, width and thickness, characteristically round, without lateral compression, non-imbricated, non-striated, endosperm yellow, flinty and externally hard, with a medium-large starchy core; midcob color present in ⅓ of ears examined; glume color present in ⅖ of ears examined; high frequency of coloration of lemmas; about 69% of the ears have colorless pericarp and white cob, the next higher frequency being 8% for colorless pericarp and red cob (AP^{wr}).

Ears, Internal Characters (Fig. 93). Ear diameter 37.3 mm.; cob diameter 22.4 mm.; rachis diameter 13.2 mm.; rachilla length very short, 1.0 mm.; cob/rachis index intermediate, 1.69; glume/kernel index intermediate, 0.42; rachilla/kernel index very low, 0.09; lower glume long, 6.3 mm.; with very slight pubescence and

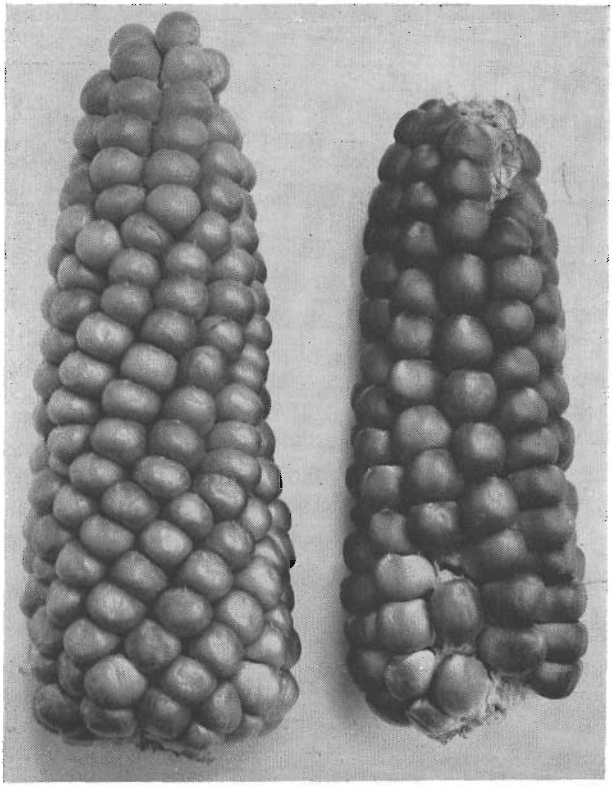


FIG. 90. Morocho, representative ears. These are characterized by round flinty, kernels and ears with a rather thick butt.

intermediate to high score for hardness; upper glume short, slightly pubescent, with intermediate score for hardness, sparsely veined, least so than any other Peruvian race; cupule medium-long, narrow, and deep with medium-high rachis flaps; rachis induration medium-low; non- or slightly tripsacoid.

Distribution (Fig. 94). The race Morocho is well distributed at intermediate altitudes of the Sierra, from 2,000 to 3,500 meters above sea level, with more than 70% of the collections coming from altitudes below 2,800 meters. Its range is divided by the high mountain region of the Departments of Junin and Cerro de Pasco (the Pasco Knob) into a northern and a southern area. The latter is concentrated in the low altitude valleys of the Departments of Ayacucho and Apurimac. The northern area has a relatively unimportant scattering in Ancash, and a high concen-

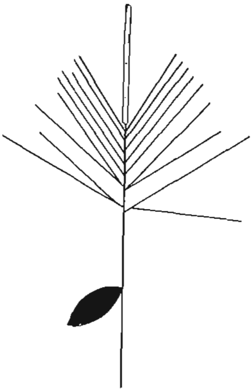


FIG. 91. Tassel diagram of Morocho.

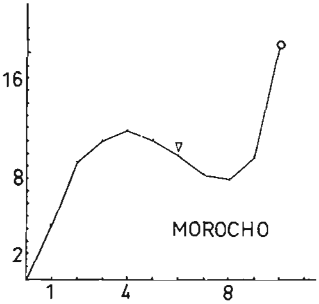


FIG. 92. Internode pattern of Morocho.

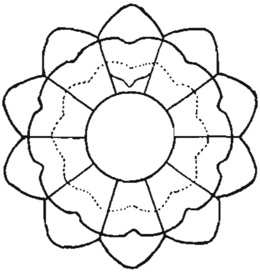


FIG. 93. Ear-cross-section dia gram of Morocho.

tration in the Departments of Amazonas, Cajamarca and La Libertad, where Morocho is sympatric to the distribution of its related race Morocho Cajabambino.

Origin and Relationships. Through references from the early Spanish Chroniclers, we may be certain of the existence of the race Morocho at the time of the Spanish Conquest. It was described as a hard flinty corn, consumed by the Inca warriors and later used by the Spaniards to feed their horses (Cobo, 1653). Tschudi (1847) mentions it as an important type of corn of the eastern Andean region of Peru. It was also grown on the Coast and in the Sierra.

Morocho is very likely one of the first, if not the first, race derived from the hybridization of Proto-Confite Morocho and Confite Chavinense, followed by recurrent back-crossing to a

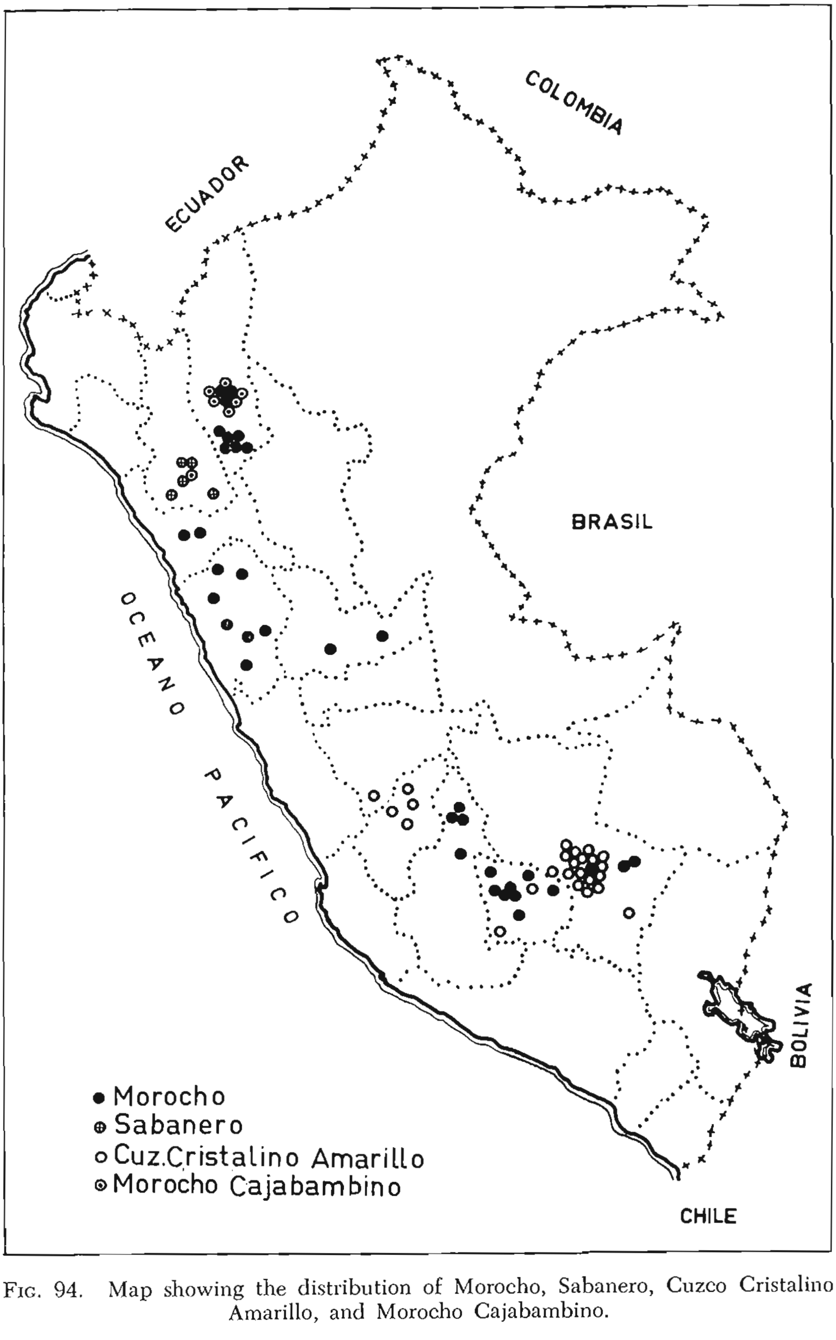


FIG. 94. Map showing the distribution of Morocho, Sabanero, Cuzco Cristalino Amarillo, and Morocho Cajabambino.

larger population of Proto-Confite Morocho, and further selection.

From both parents Morocho kept the character of flint, yellow endosperm; it still has over 13% of ears showing various shades of brown pericarp (A^b1 allele),the same that the putative parent, Confite Chavinense, or perhaps both parents, had. The irregularity of rowing and the elongate pear-shaped ear clearly indicate the fixation of an intermediate ear phenotype between a straight 8-rowed popcorn like Confite Morocho, and an irregular multi-rowed race such as Confite Chavinense. In fact, Morocho has a larger row number at the base of the ear than further up. In other characters such as presence of the Ga or Ga^S (Gametophyte) alleles, leaf venation index, tassel length and branching space, internode diagram, cupule dimensions, height of rachis flaps, rachilla length, round kernels, lacking compression, and a "lax" ear, Morocho approaches closely its putative parent Confite Morocho.

The presence of a knob on chromosome 4 long arm contrasting with its absence in Confite Morocho, together with B-chromosomes, which have not been found in Confite Morocho, might be—among other possibilities—due to an introduction from its other putative parent. Morocho itself has been the putative parent of Morocho Cajabambino and Sabanero.

The wide geographical range of this race since early agricultural periods has resulted in the subdivision of Morocho into many ecotypic races. In the northernmost area of its distribution —Departments of Cajamarca and Amazonas—one of these geographical variants is sufficiently differentiated to merit being classified as an incipient new race. This is Morocho Cajabambino.

Derivation of Name. Morocho is the Spanish corruption of the Quechua word *Muruchu* (Mejia Xesspe, 1931), the name applied to this race since pre-Hispanic times.

HUANCAVELICANO

Plants (Fig. 97). Medium short, average height 1.32 mm.; intermediate maturity, 140 days to mid-silking at altitudes similar to those of its native habitat, when grown in Cuzco (3,200 m.), to 121 days at 2,800 meters above sea level. Ear placed low to midway on the plant, averaging 56 cm. above ground, often on the fifth node up from the ground; average number of leaves 10.9;

leaves above the ear 5.1; leaves short and medium in width with a large number of veins and high venation index, 3.58, small leaf area, 2,900 sq. cm.; slight pubescence with hairs of medium size; moderately susceptible to leaf rust and resistant to Helminthosporium leaf blight; tillers absent, high seedling color index.

Tassels (Fig. 96). Medium sized peduncle; short tassel; very small branching space in proportion to total tassel length, 32.0%; relatively long central spike; medium-short tassel branches; mostly primary branching, with 20% secondary and no tertiary branching; condensation index low, 1.02.

Ears, External Characters (Fig. 95). Small, cylindro-conical, though slightly globose; eight rows (less frequently ten); average ear length 11.95 cm.; slender, medium-long shank with 7.5 husk leaves; kernels long, wide, very thick, pointed, with a slight beak, slight imbrication tendency, surface striation present; floury with white endosperm in the central area of dispersal in Huancavelica,

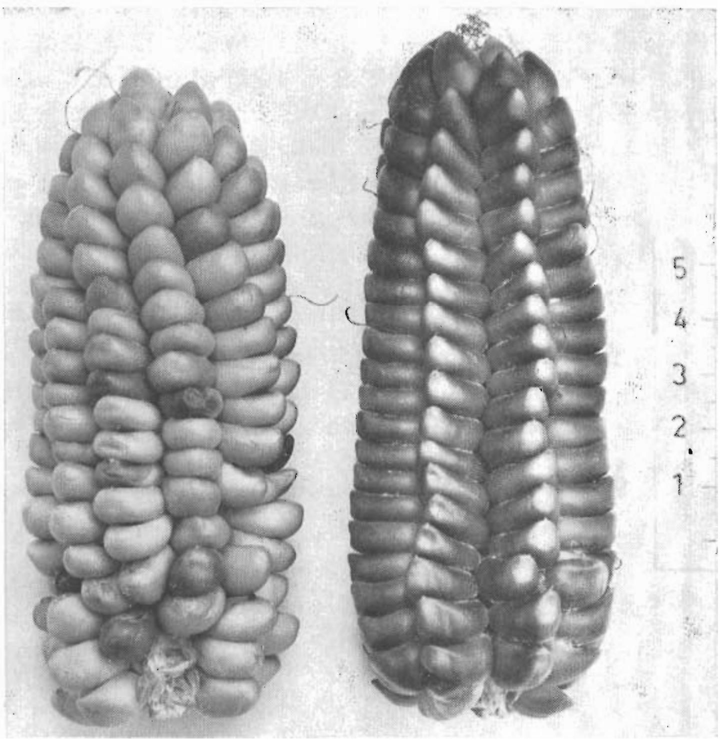


FIG. 95. Huancavelicano (Hvca. 104, and 120); typical ears. This race is postulated as one of the parents of Cuzco.

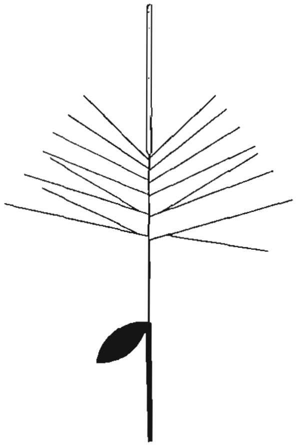


FIG. 96. Tassel diagram of Huancavelicano.

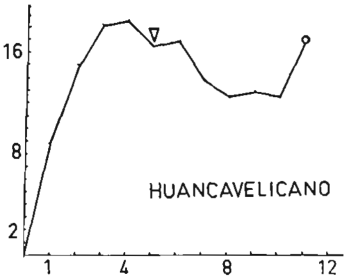


FIG. 97. Internode pattern of Huancavelicano.

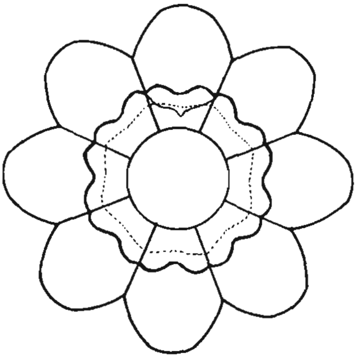


FIG. 98. Ear-cross-section diagram of Huancavelicano.

but with a yellow, flinty outer layer and a floury core in Cuzco, Apurimac and Puno; midcob color generally absent; colorless glumes and lemmas; pericarp and cob color alleles cover a large range of variability, with the following combinations present in the highest frequencies: colorless-white, 56.2%, brown-brown ($A^{b'}P^{rr}$) 13.2%, red-red (AP^{rr}) 7.9%, colorless-red (AP^{wr}) 6.8%, and variegated red-variegated red (AP^{vv}) 5.7%.

Ears, Internal Characters (Fig. 98). Average ear diameter 46.5 mm.; cob diameter 20.5 mm.; rachis diameter 13.0 mm.; pith diameter 7.0 mm.; rachilla length 1.7 mm.; cob/rachis index rather low, 1.58; glume/kernel index low, 0.25; rachilla/kernel index low, 0.11; short lower glume, medium to strongly pubescent

TABLE 11. Comparison of Huancavelicano with its Postulated Parental Races Confite Morocho and Kculli.

	C. Morocho	*Huancavelicano*	*Kculli*
Plant Characters.			
Height of Plant (cm)	127	132	92
Ear Height (cm)	56	48	29
Number of Leaves	11.9	10.9	9.5
Leaves above the Ear	5.6	5.1	5.3
Length of Leaves (cm)	53.4	55.1	58.0
Width of Leaves (cm)	6.3	8.3	7.4
Venation Index	3.80	3.04	3.31
Stalk Diameter (mm)	16.0	22.3	19.0
Days to Midsilk	116	140	137
Tassel Characters.			
Tassel Length (cm)	28.7	28.7	27.2
Length of Branching Sp. (cm)	9.4	9.2	8.8
Percent of Branching Sp.	32.7	32.0	22.1
Number of Primary Branches	10.7	11.8	10.3
Number of Secondary Branches	4.2	3.0	2.3
Number of Tertiary Branches	0.1	0	0
Condensation Index	1.00	1.02	1.00
Length of Peduncle (cm)	27.2	14.0	19.6
Ear External Characters.			
Length of Ear (cm)	6.78	11.45	9.23
Diameter of Ear (cm)	2.32	4.50	4.11
Row Number	10.66	8.75	12.00
Shank Length (cm)	5.17	6.65	6.14
Shank Diameter (cm)	0.42	1.01	0.88
Kernel Length (mm)	7.34	15.00	13.78
Kernel Width (mm)	5.87	11.60	10.27
Kernel Thickness (mm)	4.55	6.20	6.01
Ear Internal Characters.			
Cob Diameter (mm)	12.0	20.5	21.3
Rachis Diameter (mm)	5.2	13.0	15.2
Rachilla Length (mm)	1.4	1.7	0.8
Cob/rachis Index	2.30	1.58	1.40
Glume/kernel Index	0.37	0.25	0.20
Rachilla/kernel Index	0.16	0.11	0.05
Cupule Length (mm)	3.1	1.7	1.4
Cupule Width (mm)	2.9	10.8	8.1
Cupule Depth (mm)	1.4	1.5	2.4
Cupule Pubescence	1.15	1.50	1.10
Upper Glume Length (mm)	3.1	3.0	2.8
Lower Glume Length (mm)	4.2	4.2	3.1
Height Rachis Flaps	1.60	1.00	1.66
Rachis Induration	2.90	3.50	3.00

TABLE 12. Comparison of Pagaladroga with its Postulated Parental Races Confite Puntiagudo and Mochero.

	C. Puntiagudo	*Pagaladroga*	*Mochero*
Plant Characters.			
Height of Plant (cm)	116	207	153
Ear Height (cm)	49	114	93
Number of Leaves	8.7	11.6	10.4
Leaves above the Ear	4.2	5.5	3.8
Length of Leaves (cm)	56.2	76.2	75.8
Width of Leaves (cm)	6.5	9.7	8.8
Venation Index	3.69	2.54	2.74
Stalk Diameter (mm)	16.7	19.7	18.3
Days to Midsilk	125	83	69
Tassel Characters.			
Tassel Length (cm)	24.7	33.7	37.9
Length of Branching Sp. (cm)	9.1	16.2	16.8
Percent of Branching Sp.	36.8	48.7	44.3
Number of Primary Branches	9.0	21.5	23.6
Number of Secondary Branches	2.8	11.3	15.2
Number of Tertiary Branches	0	0.7	2.7
Condensation Index	1.02	1.08	1.09
Length of Peduncle (cm)	20.0	17.4	11.4
Ear External Characters.			
Length of Ear (cm)	8.86	14.31	7.63
Diameter of Ear (cm)	3.24	4.19	4.13
Row Number	15.13	15.00	Irreg.
Shank Length (cm)	7.70	7.75	6.50
Shank Diameter (cm)	—	1.10	—
Kernel Length (mm)	8.26	9.60	9.90
Kernel Width (mm)	5.35	7.80	8.60
Kernel Thickness (mm)	4.33	4.10	4.50
Ear Internal Characters.			
Cob Diameter (mm)	21.6	21.2	24.8
Rachis Diameter (mm)	12.6	12.2	16.1
Rachilla Length (mm)	1.7	1.7	2.7
Cob/rachis Index	1.71	1.74	1.54
Glume/kernel Index	0.52	0.47	0.44
Rachilla/kernel Index	0.19	0.17	0.27
Cupule Length (mm)	1.6	2.9	1.4
Cupule Width (mm)	9.9	5.9	7.9
Cupule Depth (mm)	1.4	1.3	1.1
Cupule Pubescence	1.50	1.70	1.50
Upper Glume Length (mm)	4.0	4.1	4.7
Lower Glume Length (mm)	4.8	4.2	6.1
Height Rachis Flaps	1.50	1.50	1.90
Rachis Induration	3.30	3.45	2.80

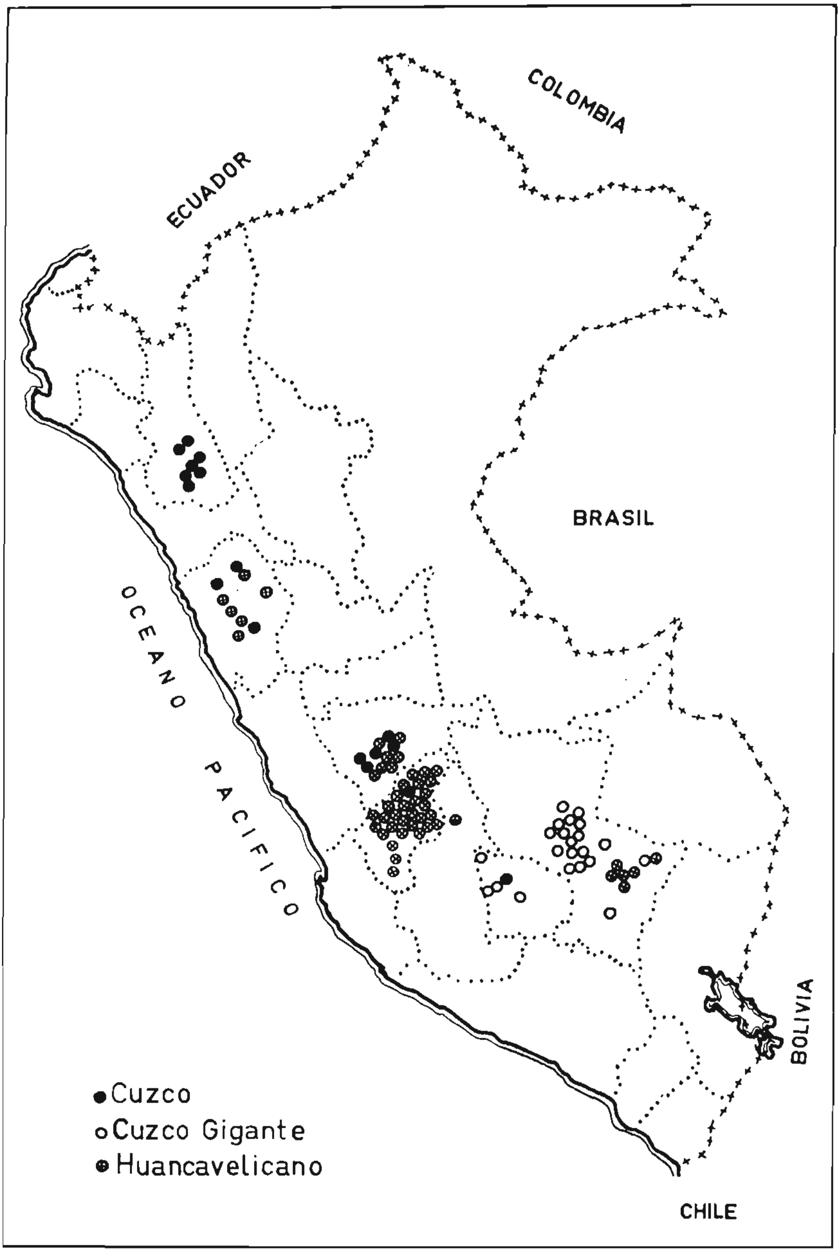


FIG. 99. Map showing the distribution of Cuzco, Cuzco Gigante, and Huancavelicano.

with relatively hard texture; short upper glume, slightly pubescent, medium-hard texture, very strongly veined; cupule length intermediate, very wide, and shallow; rachis flaps intermediate in height; rachis texture hard; slightly tripsacoid.

Distribution. Huancavelicano has a distribution centered in the Department of Huancavelica and extending sympatrically with the Cuzco race in the Departments of Apurimac, Cuzco, Ayachucho and Junin. Its northern limit is in northern Ancash, as shown in Fig. 99.

The altitudinal distribution of Huancavelicano is limited to areas between 2,200 and 3,500 meters above sea level, with nearly 80% of its collections coming from elevations above 2,800 meters.

Origin and Relationships. The general similarity of Huancavelicano and Confite Morocho, particularly in regard to the tassel, ear and kernel, is quite apparent. However, there are several diverging characters such as different internode length patterns, and different cupule types. Furthermore, Huancavelicano is a high altitude race, while Confite Morocho is generally grown at intermediate altitudes.

In order for Huancavelicano to have become established as a race at high altitudes in the south central Andes, its ancestral form must have undergone strong natural and human selection. We are postulating that Huancavelicano originated from the hybridization of two Primitive Races, Confite Morocho and Kculli. The latter was originally distributed, as today, at higher altitudes and contributed to the hybrid progency its genes for adaptation to such habitats. Of 32 characters in which Huancavelicano has been compared to its putative parents, it is intermediate in 19, and exhibits residual heterosis where it would be expected in nine others. Of the nineteen intermediate characters, eight approach more closely one parent, while seven approach the other (Table 11).

Apparently regional specialization produced an early separation of a cherry pericarp and purple cob sub-race from a colorless pericarp and white cob sub-race. Modern Huancavelicano has been strongly selected for colorless pericarp and white cob. The sub-race Cuzco Morado approaches Huancavelicano so closely in ear appearance that it leads us to postulate the existence in a not too distant past of a sub-race of Huancavelicano with distinct cherry pericarp ears.

Huancavelicano has participated in the formation of the races Cuzco, Cuzco Cristalino Amarillo and Cuzco Gigante, and it may be definitely placed as originating long before the period of the Spanish Conquest. On account of the time requirement necessary for the formation of the Cuzco race, which was described by even the early Spanish chroniclers, Huancavelicano must have originated as one of the group of Anciently Derived races early in the development of agriculture in the southern highland areas of Peru.

Prehistoric stone replicas with a star-shaped cross section typical of ears of Huancavelicano may be found in private collections in Lima. At least one such specimen that came to our attention had been found on the Coast at a late archaeological site in the Chancay valley. This suggests the influence of Huancavelicano, complementary or alternative to that of Cuzco, on corn of the coast.

Derivation of Name. From the name of the Department of Huancavelica, center for the geographical distribution of this race.

MOCHERO

Plants (Fig. 102). Short plants, average height 1.53 m., very early, averaging 80 days to silking on the Central Coast, and from 65 to 70 days in its native habitat on the North Coast; average number of leaves 10.4, of which 3.8 are above the ear; height of ear 0.93 m., on sixth node above ground; leaves rather long, medium wide, with medium large venation index, 2.74; low leaf area, 2,400 sq. cm.; stalk of narrow to intermediate width, tillers occasionally present, and then very small; stalk color green; high resistance to leaf rust and Helminthosporium leaf blight.

Cytological Characteristics. A medium sized intercalary knob is present with a frequency of 65% on chromosome 7L. A medium sized intercalary knob on chromosome 4 long arm, and a terminal knob on chromosome 9 short arm, have a 12% frequency, and a subterminal knob on chromosome 9 short arm has a frequency of 5.5%. Only one plant out of 17 studied had one B-chromosome, while the others had none.

Tassel (Fig. 101). Short peduncle, 11.4 cm., large tassel with a length of 37.9 cm.; large branching space, 16.8 cm. and 44.3% of the total tassel length; long branches, with large number of

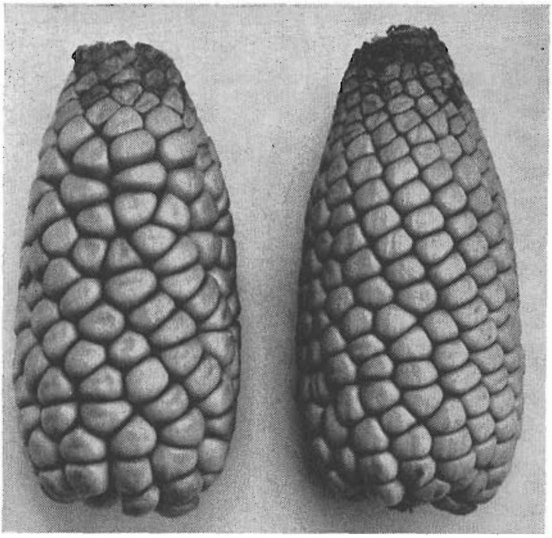


FIG. 100. Mochero (Lbque. 7); typical ears. This is an early drought resistant race from the North Coast.

primaries 23.6, secondaries 15.2, and tertiaries 2.7, the latter in larger number than in any other race, condensation index low, 1.09.

Ears, External Characters (Fig .100). Short, stubby, cylindrical, rounded at the bottom, tapering slightly at the tip, average length 7.63 cm.; kernels irregularly arranged following an approximately spiral disposition and approaching 14 rows; short slender shank, with low number of shank nodes; large number of husk leaves, 9.43; kernels short, of medium width and thickness, multilaterally compressed, giving polyhedrical appearance on upper (cap) view; floury, white endosperm, occasionally with purple and rarely with bronze aleurone color; slight surface depression and strong striation; midcob color present in ⅓ of ears; half of the ears with red glumes and half colorless; all ears examined had no color on the lemmas; pericarp and cob color frequencies are the following: colorless-white 43.6%, brown-brown $(A^{b'}P^{rr})$ 12.8%, variegated red-variegated red (AP^{vv}) 15.4%, red white cap-red (AP^{cr}) 7.7%, red-red (AP^{rr}) 7.7%, colorless-red (AP^{wr}) 5.1%, and others less frequently (Table 6A).

Ears, Internal Characters (Fig. 103). Average ear diameter 41.3 mm.; cob diameter 24.8 mm.; rachis diameter 16.1 mm.; pith

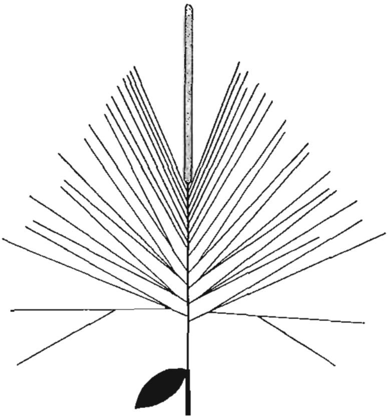


FIG. 101. Tassel diagram of Mochero.

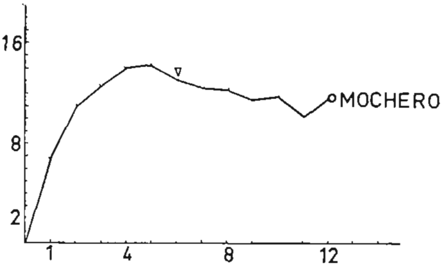


FIG. 102. Internode pattern of Mochero.

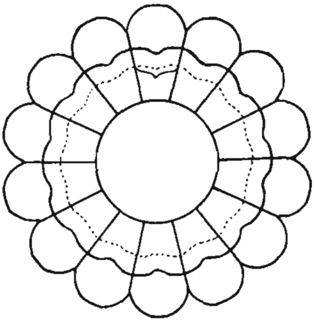


FIG. 103. Ear-cross-section diagram of Mochero.

diameter 9.4 mm.; rachilla length intermediate, 2.7 mm.; cob/rachis index low, 1.54; glume/kernel index intermediate, 0.44; rachilla/kernel index medium, 0.27; medium long lower glume, sparsely haired, with medium-high hardness; medium-long upper glume, with few hairs, very soft texture, and strong venation; cupules very short, shallow, and wide; very high rachis flaps; low rachis induration; non-tripsacoid.

Distribution (Fig. 104). Mochero has a limited distribution in the North Coast Departments of La Libertad, Lambayeque and Piura, at altitudes not over 50 m. above sea level. Its largest concentration is found in the small dry valleys of the "Pueblos" area north of the city of Chiclayo, where it is irrigated by the summer or *avenida* waters of small, irregularly flowing rivers. Its

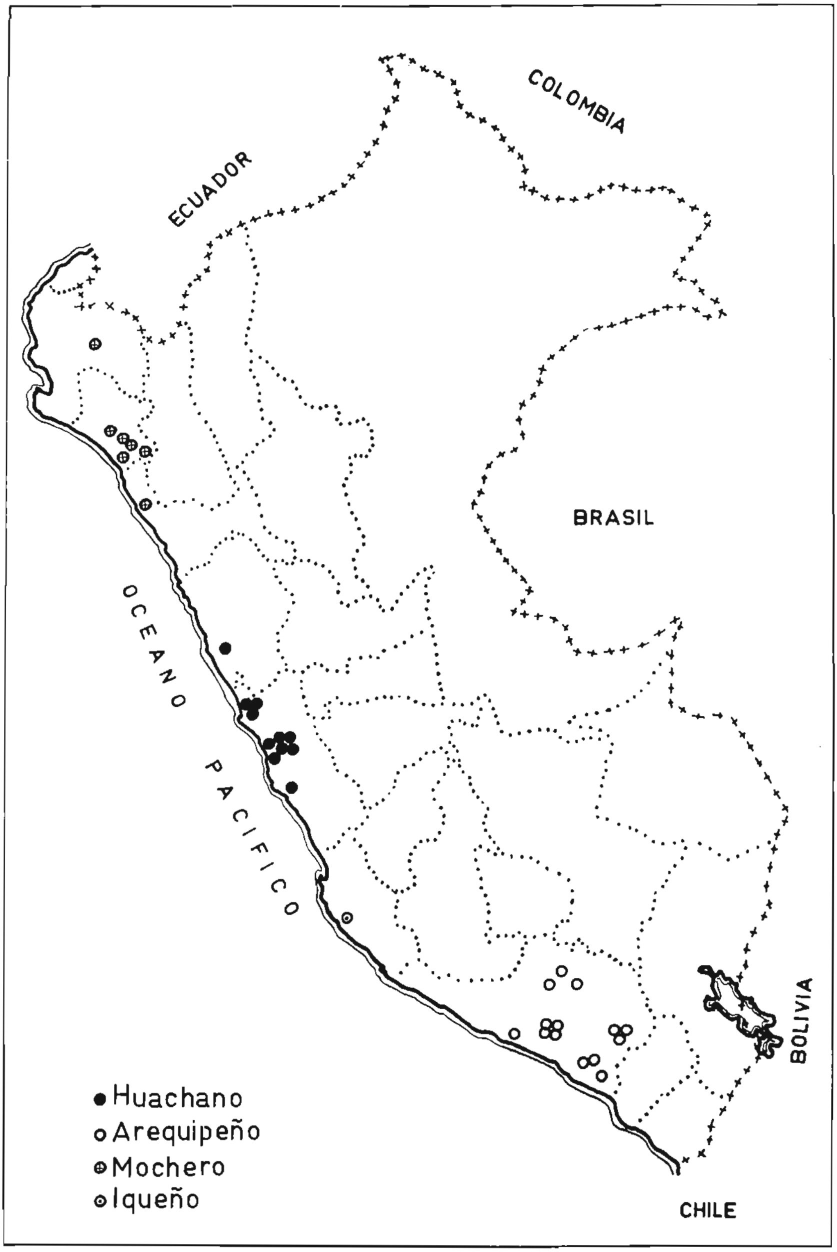


FIG. 104. Map showing the distribution of Arequipeño, Huachano, Iqueño, and Mochero.

early vegetative period allows it to be harvested only three and a half months after planting. It usually receives one, or at the most two irrigations, including the one for land preparation. For better water penetration and storage in the deep silty clay soils of the North Coast, Mochero is grown in medium to large plots separated by small earth dams or boulders, which are flooded with water during each irrigations.

On the North Coast, Mochero is second only to the race Alazan as a raw material for the local preparation of *chicha*, or corn beer.

Origin and Relationships. There is ample evidence for the existence of Mochero as a distinct race (Proto-Mochero) in prehistoric times in the same area where it is found today. Such evidence has been presented elsewhere in this monograph.

Undoubtedly Mochero is a direct descendant of the early popcorn grown on the coast with very limited out-crossing preceding its formation. It probably did not differentiate as a floury race, however, until the immediate pre-Mochica Period. The availability of material of Confite Iqueño at Los Cerrillos, Ica, from a Period antedating the probable appearance of Mochero, has permitted a general comparison of the former race with its postulated descendant, Mochero. In plant characters there is a close correspondence between the two races. The ears of Mochero appear as a floury, enlarged version of the ears of its popcorn parent. Furthermore, the cytological analysis reveals Mochero as a race belonging to the essentially low-knobbed group, a classification which it shares with Pagaladroga, another Anciently Derived Race grown in the same geographical area. It is very likely that some hybridization has occurred between these two races. A few inbred lines derived from Mochero exhibit typical Pagaladroga ears.

Mochero is the parent of a complex of similar floury races, widely distributed along the whole length of the Peruvian coast. This group of related races that we are naming, *Early Coastal Floury* or *Blancos Criollos*, is represented today by Mochero on the North Coast; by Huachano and the sub-races Iqueño and Chilcano of the race Chaparreño, on the South Coast. Starting from a similar genetic background, each of these races has diverged through hybridization with other races in each particular valley or area. Little, if any, exchange of genes has occurred between these related races after they hybridized with their respective exotic sources, but they still maintain a large store of phenotypic resemblances such as earliness, growth habit, plant, ear, kernel, and tassel characters, low chromosome knob number, with the few knobs present on chromosome 6, 7, and 9, and presence of B-chromosomes.

Derivation of Name. Since no particularly general name other than Blanco Local was given to this race by farmers, the name Mochero with which some of the first collections from the valley of Moche, Department of La Libertad, were registered, was extended to include the whole race.

PAGALADROGA

Plants (Fig. 107). Tall, average height 207 cm., early to intermediate in maturity, 103 days to mid-silking; average number of leaves 11.6; intermediate in length and relatively wide; number

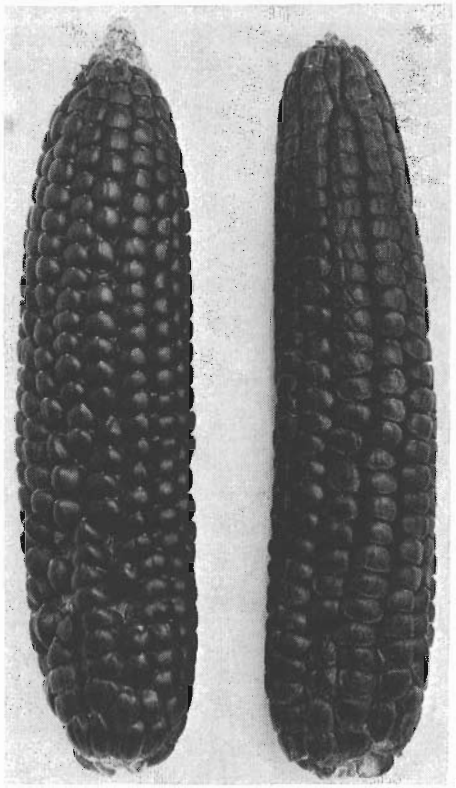


FIG. 105. Pagaladroga (Lib. 24); typical ears.

of leaves above the ear node 5.5; leaf area low; venation index intermediate; ear position central, 114 cm. from the ground; good development of tap roots with an average number of 1.35 whorls, stalk with intermediate width; predominating plant color green; occasional tillers; intermediate susceptibility to rust and Helminthosporium.

Cytological Characteristics. Only one small knob, intercalary on the long arm of chromosome 7, present in two of the three collections that were studied. No B-chromosomes.

Tassels (Fig. 106). Length of peduncle intermediate; long branching space, 16.2 cm., and in proportion to total length of tassel, 48.7%; profusely branched with rather long primary and secondary branches, and relatively large number of tertiaries; condensation index low.

Ears, External Characters (Fig. 105). Slender, cylindrical, average length 14.3 cm., with slight taper toward the tips; from 12 to 16 rows, average 15, frequently irregularly arranged; shank rather thick with intermediate length and number of nodes; number of husk leaves large, average 8.25; kernels small in length, width, and thickness, somewhat imbricated; surface depression slight or absent, strongly striated; kernel hardness score high; endosperm white, floury with flinty outer layer; aleurone color absent; pericarp and cob colors red-red (AP^{rr}) 70%, brown-brown $(A^{b'}P^{rr})$ 20%, red white cap-red (AP^{cr}) 10%. A pure colorless-white collection has recently been found on a farm near Lambayeque.

Ears, Internal Characters (Fig. 108). Average ear diameter 35 mm.; average cob diameter 21.2 mm.; average rachis diameter 12.2 mm.; estimated rachilla length short, 1.7 mm.; cob/rachis index intermediate, 1.74; glume/kernel index high, 0.47; rachilla/kernel index low, 0.17; small pith; lower glume short, slightly pubescent, with a soft medium texture; upper glume short, slightly pubescent, with a rather soft texture, and a very low venation index; red color of glumes 60%; color of lemmas red 70%, rest colorless; midcob color absent in all ears that were studied; cupules small in all three dimensions; height of rachis flaps intermediate; induration of rachis tissues intermediate; tunicate allele (tu^{w}), tripsacoid characters low to medium expression.

Distribution (Fig. 109). Pagaladroga is distributed in the north-

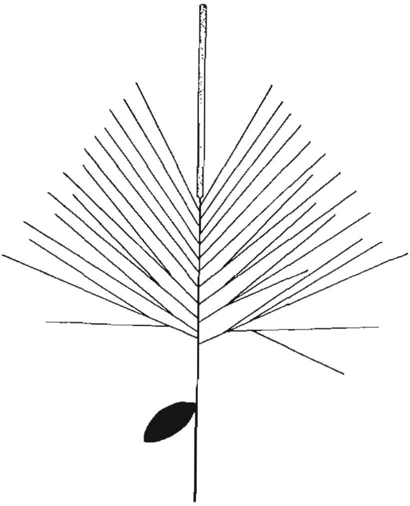


FIG. 106. Tassel diagram of Pagaladroga.

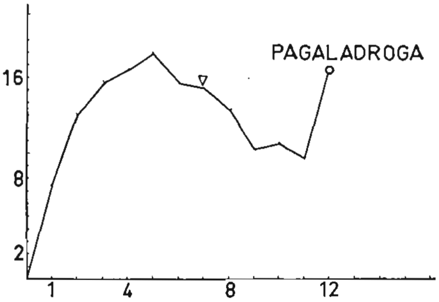


FIG. 107. Internode pattern of Pagaladroga.

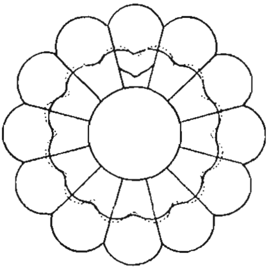


FIG. 108. Ear-cross-section diagram of Pagaladroga.

ern coastal valleys, particularly from Trujillo to Piura. It is almost extinct now, but a very few farmers still grow mixed lots of Pagaladroga with Alazan corn, particularly in the small "Pueblos" area of the very dry La Leche river valley, north of the town of Lambayeque. It is more water requiring than the more common Mochero corn, a reason why in water scarce Lambayeque it has not been held in good esteem by local farmers.

Origin and Relationships. This race as Proto-Pagaladroga was probably widespread on the North and Central Coasts of Peru during the Formative and Classic Epochs. The abundance of actual ear material and pottery moldings (Fig. 27) found in

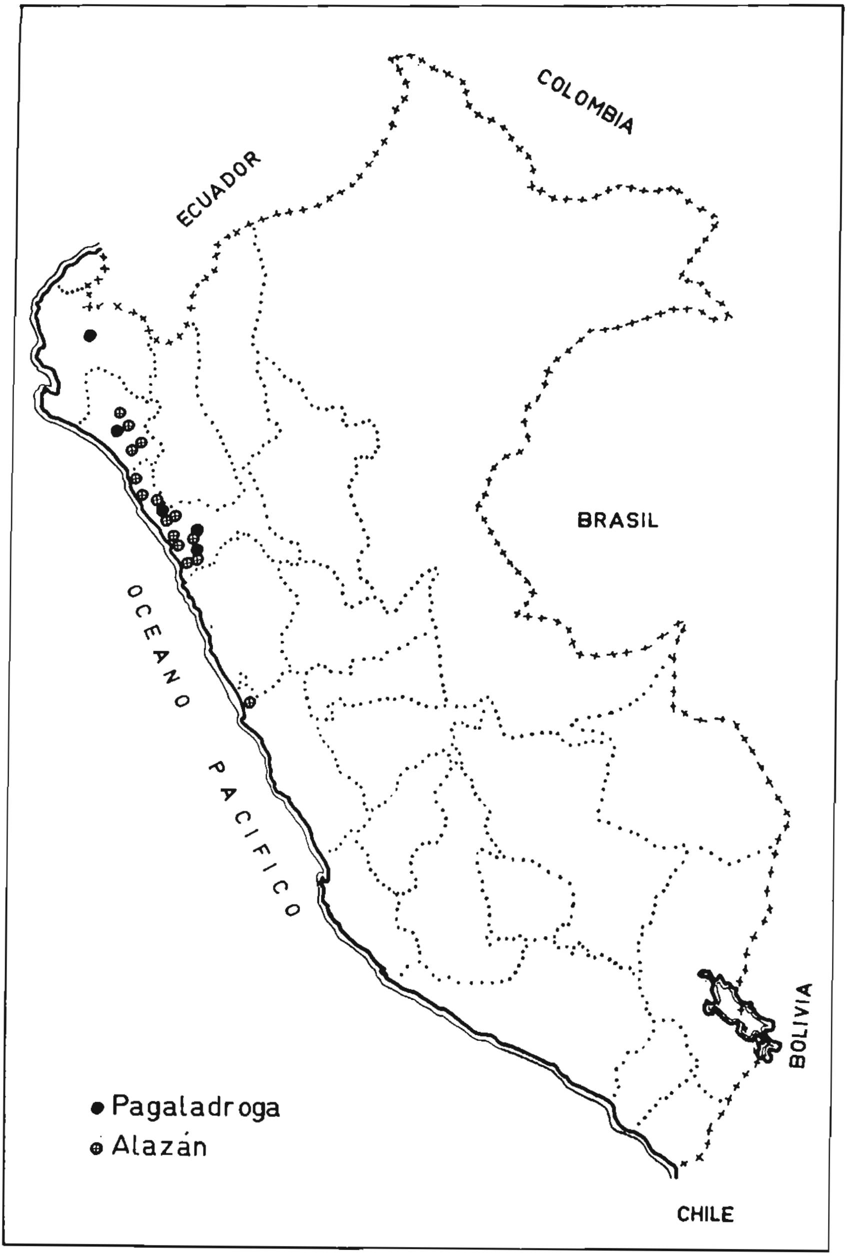


FIG. 109. Map showing the distribution of Alazan and Pagaladroga.

archaeological sites resembling present day Pagaladroga leads us to this belief.

Pagaladroga was derived on the northern Peruvian Coast from an ancestor similar to present-day Confite Puntiagudo, which very likely had a red pericarp color, such as exhibited by prehistoric corn specimens and by present day Pagaladroga. In this connection, it is interesting to observe that in Colombia, the northern peripheral area of distribution of Confite Puntiagudo, its local racial counterpart, named Imbricado, possesses a red pericarp color. The other parental race was very likely Confite Iqueño, ancestor of the race Mochero, or an incipient form of Mochero.

It is conceivable that Confite Puntiagudo hybridized with the ancestor of present day Mochero to give Pagaladroga. Table 12 indicates the similarity of biometrical data of present day Pagaladroga and its putative parents Mochero and Confite Puntiagudo. It should be borne in mind that, since the original hybridization and subsequent selection, all three races must have evolved considerably to achieve their modern form.

Pagaladroga is one of the parents of Alazan, a race of the North Coast of Peru.

Derivation of Name. Pagaladroga or *Pagadroga*, Spanish names with which this race is designated (meaning "buy the drug") are perhaps a corruption of its former, pre-hispanic local name. It is also occasionally referred to as Putita and Aleli.

CHAPARREÑO

Plants (Fig. 112). Medium short, average height 1.72 m.; early, with 83 days to mid-silk in summer plantings, and an average of 94 days in winter plantings on the Central Coast; average number of leaves 12.1, of which 5.1 are above the ear; leaves very long and wide, with medium venation index; medium-high leaf area 6,146 sq. cm.; stalk thick, with slight hairiness, green, and lacking tillers; leaf pattern index high Quadrant II; ears placed on the sixth node above ground, at a mean height of 0.98 m., resistant to both rust and Helminthosporium.

Cytological Characteristics. Medium knob on chromosome 7, subterminal on the long arm in ⅔ of plants examined, and small terminal knob on the long arm of chromosome 7 in ⅓ of plants;

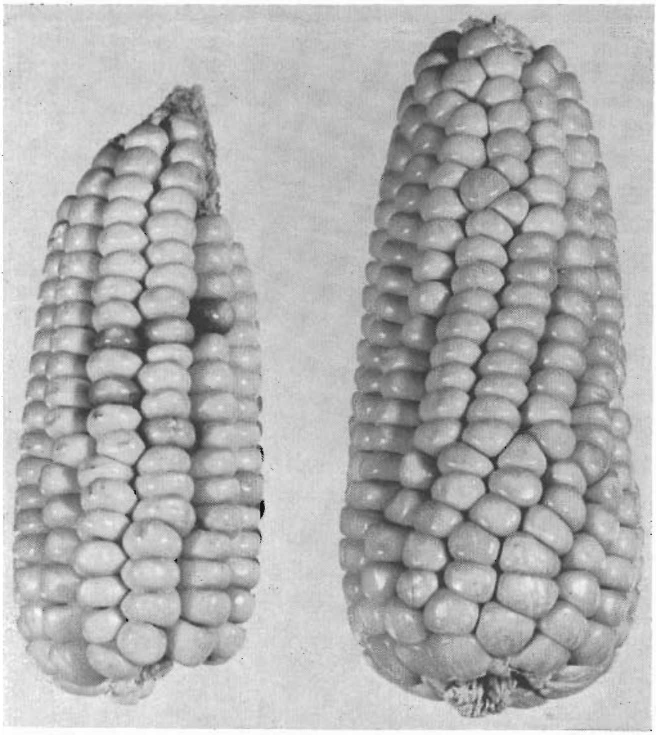


FIG. 110. Chaparreño, typical ears. This race is presumably derived from the hybridization of the sweet corn ancestor Proto-Chullpi with the primitive Coastal popcorn Confite Iqueño. It is an early, floury, summer corn.

⅓ of the plants knobless. One or two B-chromosomes in ⅔ of plants.

Tassels (Fig. 111). Large, with medium-large branching space, medium-long branches, large number of primary, secondary, and tertiary branches; condensation index low, 1.00.

Ears External Characters (Fig. 110). Cylindrical, tapering slightly from base to tip, slightly globose in appearance, short, average length 10.5 cm., average number of rows 14, but often exhibiting an irregular distribution of kernels: shank length and diameter intermediate, number of shank nodes intermediate; large number of husks, 10.3; kernels intermediate in length, although some collections from the Tambo valley have unusually long and rather narrow and thin kernels, very much like those of Chullpi; non-imbricated, although dispaying a slight upward

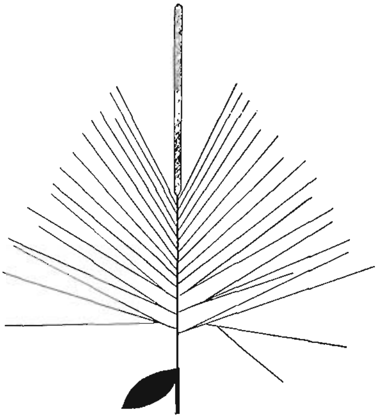


FIG. 111. Tassel diagram of Chaparreño.

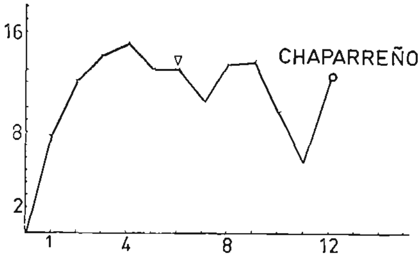


FIG. 112. Internode pattern of Chaparreño.

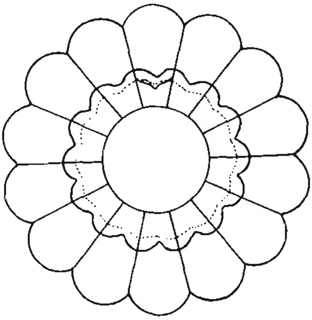


FIG. 113. Ear-cross-section diagram of Chaparreño.

beak; medium kernel depression; medium-strong striation; endosperm floury white, sometimes yellow, very soft, occasionally showing purple aleurone color; midcob color absent; red and brown glume color present, as well as red and colorless lemmas; pericarp color usually absent, cobs white.

Ears, Internal Characters (Fig. 113). Average ear diameter 41.1 mm.; cob diameter 23.0 mm.; rachis diameter 14.1 mm.; pith diameter 7.9 mm.; estimated rachilla length medium, 2.5 mm.; cob/rachis index medium, 1.65; glume/kernel index low, 0.40, rachilla/kernel index medium, 0.22; very short lower glume with intermediate degree of hairiness, and rather hard texture; very short upper glume, weakly pubescent with soft texture, and strong venation; cupules small in their three dimensions, with

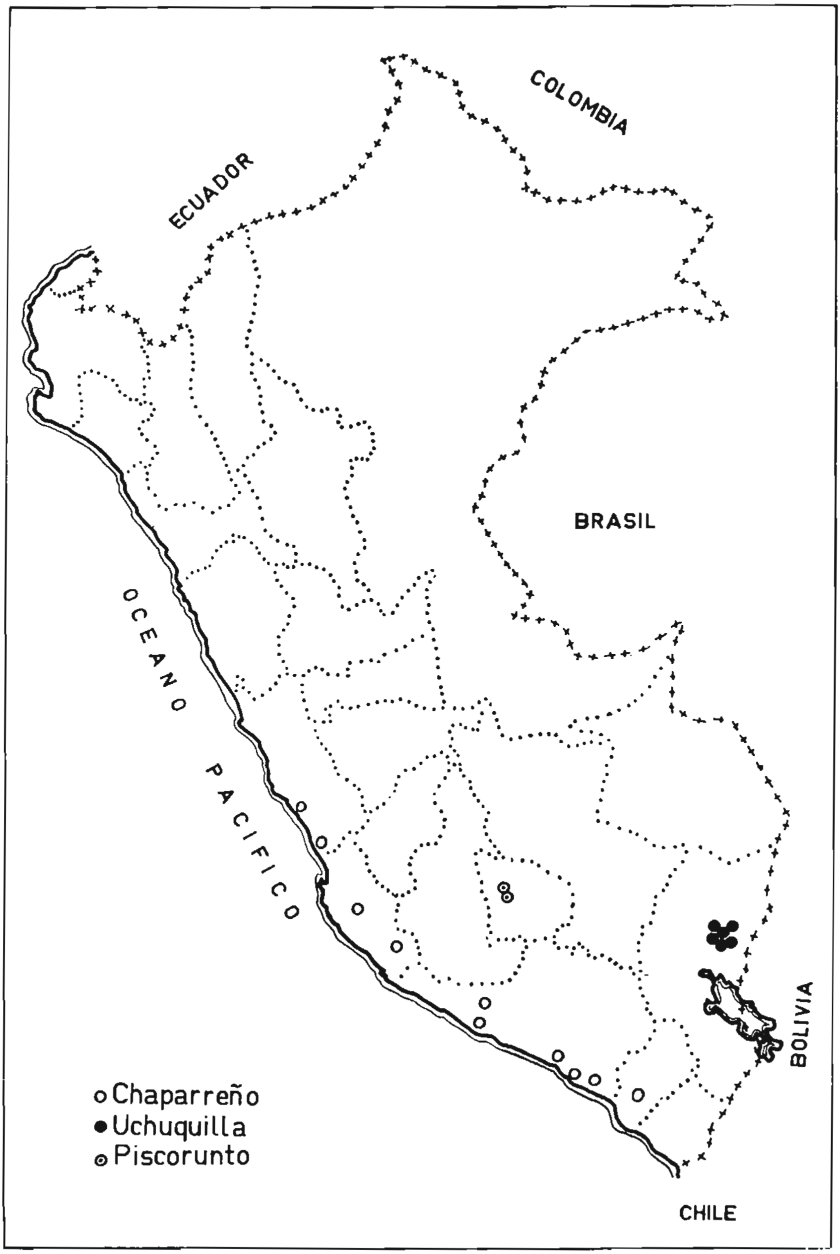


FIG. 114. Map showing the distribution of Chaparreño, Pisccorunto, and Uchuquilla.

relatively large hairiness, high rachis flaps, medium rachis induration; slight expression of tripsacoid characters.

Distribution (Fig. 114). Chaparreño is distributed at low altitudes in all the valleys between the Tambo in the Department of Arequipa and the Rimac near Lima.

Origin and Relationships. Chaparreño is one of the Anciently Derived races of the *Early Coastal Floury* group and has been in existence on the Peruvian coast for a long time. Its origin may be found in the hybridization of a floury derivative of Chullpi, or of the race Chullpi itself, with a floury derived form of Confite Iqueño.

Available archaeological evidence from late Paracas and Nazca sites indicates the appearance of a deeply dented corn with irregular kernel arrangement, and slightly beaked kernels (Figs. 20, 21). At approximately 1000 to 1200 A.D. Chaparreño was already in existence as a distinct race, as evidenced by the archaeological ears of maize recovered at La Rinconada near La Molina, Lima (Fig. 24).

Several interesting similiarities link Chaparreño to Chullpi. Such characters are relatively small thickness and great length of kernels, shape and denting of kernels, irregularity of rows, short ears, cob/rachis index, rachilla/kernel index, type and dimension of cupules, and height of rachis flaps in both races.

Although Chaparreño has been selected for Chullpoid ear characters, probably environmental limitations of lack of rainfall, and short periods of available irrigation water, which forced skewness of segregation distributions toward earliness, contributed to retain the plant characters of the coastal parent. A comparison of the internode diagram pattern of Chaparreño and Mochero (Figs. 112, 102) indicates a close relationship as would be expected, since they were both derived from Confite Iqueño.

Alterations in the Chaparreño internode pattern have apparently followed additional gene flow from Cuzco. The long last internode is presumably maintained from Chullpi, while the depression in length of the previous two internodes, characteristic also of the Cuzco racial complex, could have come from additional, but limited, gene flow from the latter race. It is likely that it took place through reverse gene flow from Arequipeño. Chaparreño, as well as the other races of the *Blancos Criollos* group has a low number of chromosome knobs.

Four sub-races are distinctly recognized: Chaparreño proper, localized in the coastal valleys of the Department of Arequipa with the exception of the Tambo valley, where Clavijo is the prevalent sub-race; Iqueño grown in the Ica and Nazca (Rio Grande) valleys of the Department of Ica, and Chilcano, grown in the valleys between Pisco and Rimac.

Derivation of Name. Chaparreño, is the name commonly applied by local farmers to varieties of this race. It originated from the name of the valley of Chaparra, Department of Arequipa, where this race of corn is intensively grown.

RABO DE ZORRO

Plants (Fig. 117). Tall, average height 1.71 m.; late plants with an average of 88 days to silking when grown at La Molina (250 m. above sea level), and 142 days at Cuzco (3,200 meters); number of leaves 11.8, of which 5.2 are above the ear; leaves medium-long, 61.1 cm., medium-wide, 8.74 cm.; venation index medium-high, 2.78; low leaf area; stalk intermediate in thickness, 18.2 mm., without tillers; dilute sun red color; slightly pubescent with hairs of medium length. Leaf sheaths conspicuously separated from the stalk at the blade end, leaving a funnel-like opening between the sheath and the stalk. Intermediate resistance to rust and Helminthosporium leaf blight; low seedling color index.

Cytological Characteristics. One medium to medium-large intercalary knob present on chromosome 7L, with a frequency of 70%; one medium-large to small intercalary knob on chromosome 6L, with a frequency of 43%; one small intercalary knob on chromosome 1S, one medium-small intercalary knob on chromosome 2S, one small terminal knob on chromosome 9S, and one large knob intercalary on chromosome 9L. The number of knobs per chromosome complement ranges from 0 to 3, with plants having 1, 2 or 3 knobs in equal frequencies. Number of B-chromosomes ranges from 0 to 4, with no B's as the most frequent class.

Tassels (Fig. 116). Medium peduncle, 16.0 cm.; medium size tassel, 32.8 cm.; branching space large, 15.6 cm.; 47.6% of total length; large number of primary and secondary branches and a few tertiaries, condensation index low, 1.04.

Ears, External Characters (Fig. 115). Medium-long, average

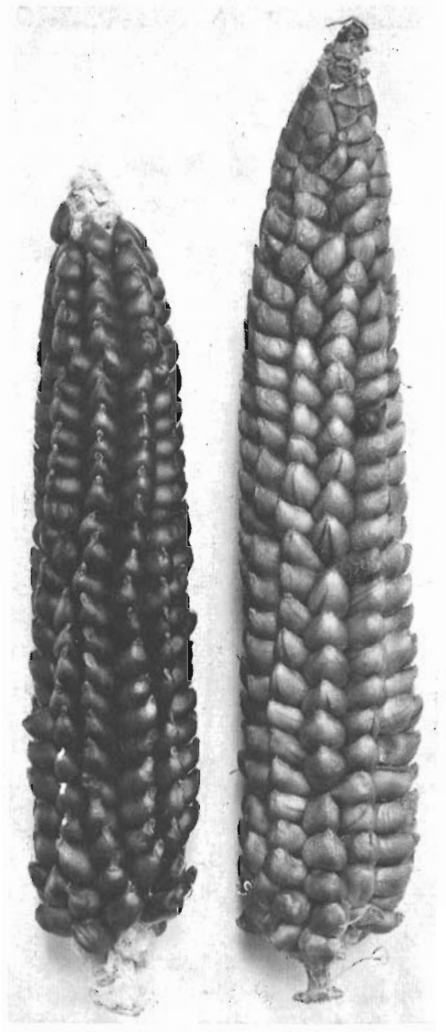


FIG. 115. Rabo de Zorro (Jun. 57); typical ears. These have a slender cob and are very flexible. Rabo de Zorro has had an important role in the evolution of corn in Peru.

18.5 cm.; cylindrical with slight tapering at the tip, often bent, and extremely flexible, exceeding in this character any other known race; with an average of 10.4 rows; shank long, 8.14 cm., of intermediate width with a large number of husks, 9.38; kernels rather small, length 12.8 mm., width 7.90 mm., thickness 5.69 mm., slightly imbricated, without surface striations; floury, white endosperm; midcob color absent in 62% of ears; red glumes in 75% of ears; red lemmas in 55% of ears. Pericarp and cob color distributions as follows: colorless-white 34.5%, red white cap-white (AP^{cw}) 16.4%, brown-brown ($A^{b'}P^{rr}$) 19.9%, brown white cap-brown ($A^{b'}P^{cr}$) 7.2%, other combinations present in lower frequencies (Table 6A).

Ears, Internal Characters (Fig. 118). Average ear diameter 34.8 mm.; cob diameter 17.8 mm.; rachis diameter 8.2 mm., second in slenderness only to Confite Morocho among Peruvian races; pith diameter 3.1 mm.; estimated rachilla length intermediate, 1.8 mm.; cob/rachis index very high, 2.17, second highest among all living Peruvian races; glume/kernel index low, 0.42; rachilla/kernel index low, 0.15; lower glume of intermediate length, medium pubescence, very soft; upper glume long, slightly pubescent, of very soft texture, low degree of venation; cupules very long, narrow and deep, boat-shaped, non-compressed and interlocked giving a very lax type of rachis; medium high rachis flaps; slight rachis induration; non-tripsacoid.

Distribution (Fig. 119). Rabo de Zorro is grown at altitudes from 2,300 to 3,200 meters above sea level, with an average of 2,860 meters. It is found in its purest form in the Marañon river valley in the Departments of Ancash and La Libertad. It has also been collected at similar altitudes on the eastern slopes of the Andes in the Department of Junin, and at lower altitudes in the Department of Apurimac, and the valley of La Convencion in Cuzco.

The distribution of Rabo de Zorro covers, therefore, a large geographical area, but is limited to the intermediate altitudes of the eastern Andean slopes. The areas where it has been collected are usually removed from highways and population centers and, therefore, are free from massive corn exchange and contamination, a factor which has contributed to the maintenance of its unusual racial characteristics.

Origin and Relationships. Rabo de Zorro undoubtedly descended directly from Confite Morocho. Both races exhibit a marked degree of similarity particularly in their plant and internal ear characters. External ear and tassel characters vary quantitatively insofar as Rabo de Zorro has undergone hybridization and subsequent selection which has modified the overall plant, ear, and tassel dimensions.

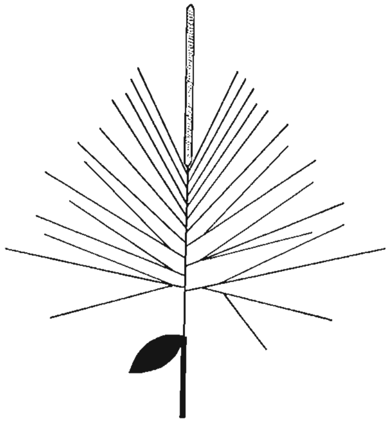


FIG. 116. Tassel diagram of Rabo de Zorro.

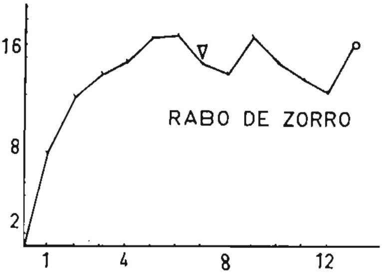


FIG. 117. Internode pattern of Rabo de Zorro.

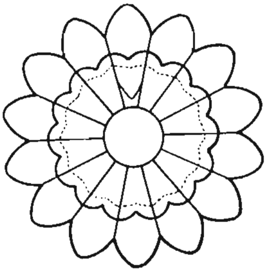


FIG. 118. Ear-cross-section diagram of Rabo de Zorro.

We may postulate that Rabo de Zorro originated from Confite Morocho through limited hybridization with a sparsely lignified sub-race of Proto-Confite Puntiagudo. The following evidence favors this interpretation: intermediate internal ear characters, such as cob/rachis, glume/kernel, rachilla/kernel indices; cob, rachis and cupule dimensions; row number; internode pattern; and cytological characters such as presence of B-chromosomes and intercalary knob on chromosome 9 long arm in both Confite Puntiagudo and Rabo de Zorro. Knobs on chromosomes 1 and 2 have been found in Rabo de Zorro, but not in Confite Puntiagudo, and on chromosomes 4 and 8 in Confite Puntiagudo, but not in Rabo de Zorro. It may well be that more extensive sampling will disclose the presence of these knob positions in both races. Another possibility is that the non-common knob posi-

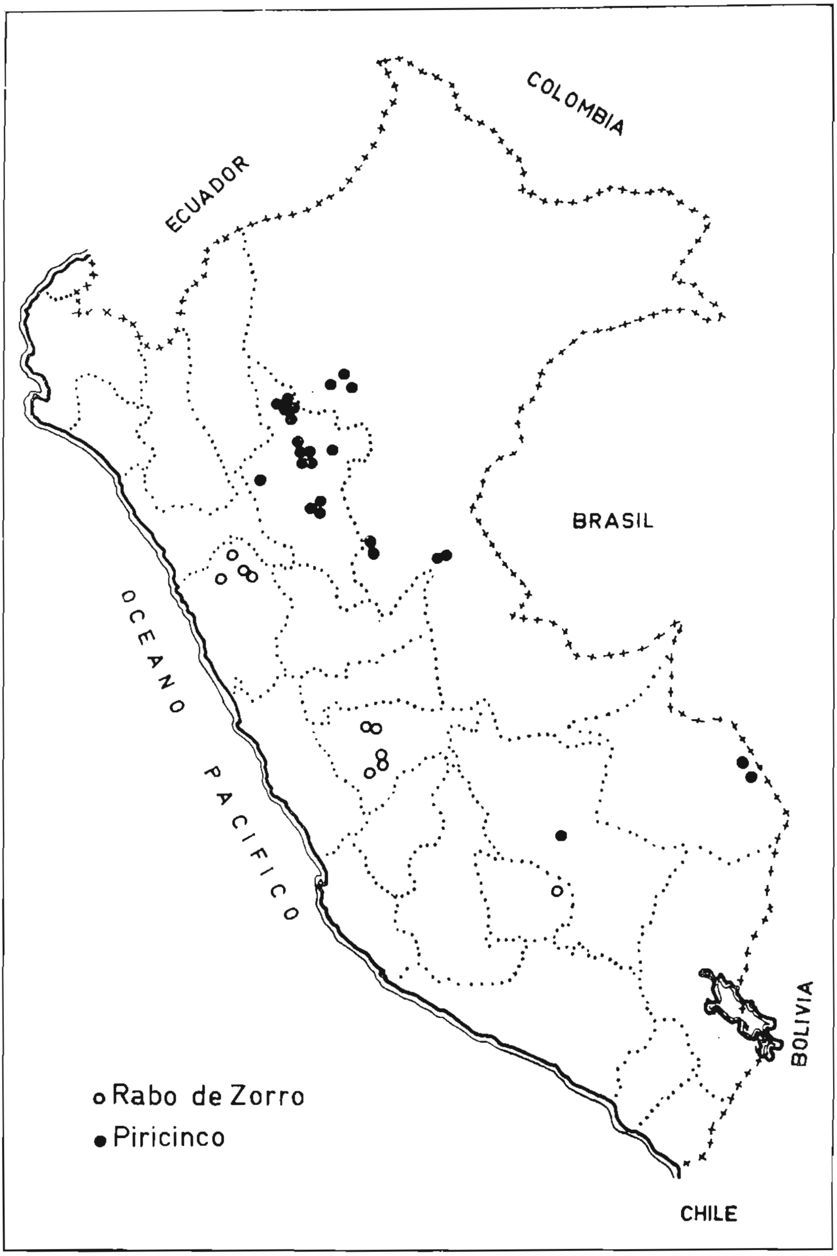


FIG. 119. Map showing the distribution of Rabo de Zorro and Piricinco.

tions were acquired by these races in periods subsequent to their hybridization. Still another explanation, and one which would additionally shed light on the origin of certain other characters in Rabo de Zorro, is that Piricinco, a race derived from Rabo de Zorro, has contributed by reverse gene flow to its parent race some of its own hybrid characters and those of its other parent, Enano. The terminal knob position on chromosome 9 short arm, as well as the pronounced plant vigor, loose sheath and its slight pubescence and tassel vigor, could have been passed on from Piricinco to Rabo de Zorro. Rabo de Zorro has given rise to the following races: Rienda, Marañon, Piricinco, Chimlos and Ancashino.

Derivation of Name. The name Rabo de Zorro meaning "fox tail" is generally given in several regions of Peru to ears which display flexibility, and more particularly to a flint corn derived from the highland Rabo de Zorro, in the Huarmey, Nepeña and Casma valleys. Since the lowland flexible corn race is also known as Rienda, we have preferred to restrict the use of the name Rabo de Zorro to the floury highland race described here.

PIRICINCO

Plants (Fig. 122). Medium height, average 1.66 m., medium maturity period, averaging 96 days to mid-silk date when grown at La Molina; number of leaves large, average 12.3, of which 5.2 are above the ear node, leaves wide and intermediate in length, venation index low, 2.6, leaf area low; ears located on eighth node, at an average height of 1.0 meter above ground; stalk medium in diameter with occasional tillers; slight leaf sheath pubescence, with soft hairs, leaf sheath open and separated from the stalk at the base of the blade; plant color most frequently is dilute sun red; resistant to both rust and Helminthosporium leaf blight; seedling color index very low.

Cytological Characteristics. One knob of variable size subterminal on chromosome 7L, with a frequency of 71.5%; one large knob subterminal on chromosome 4L, with a frequency of 28.5%, one medium knob subterminal on chromosome 2S, frequency 14.3%; one large knob subterminal on 8L, frequency 14.3%; totally knobless plants occur with a frequency of 14.3%; one large knob terminal on 9S, frequency 14.3%; most frequent knob-class is one knob per nucleus, in 43% of plants; B-chromo-

FIG. 120. Piricinco (Sn. Mtn. 9); typical ears. This race has long ears with a prominent butt, and kernels with bizarre aleurone and endosperm colors. It strongly exhibits tripsacoid characters, and is low in chromosome knob number.

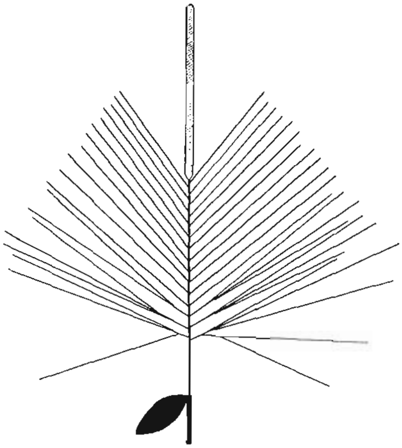


FIG. 121. Tassel diagram of Piricinco.

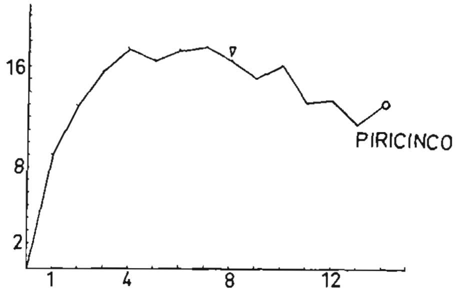


FIG. 122. Internode pattern of Piricinco.

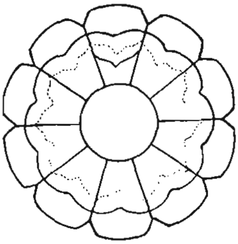


FIG. 123. Ear-cross-section diagram of Piricinco.

somes were found present with a frequency of 14.3%, up to two per nucleus.

Tassel (Fig. 121). Peduncle short; tassel size medium; branching space very large; branches medium to long, with very large number of primary and secondary, and a large number of tertiary branches; condensation index low, 1.04.

Ear, External Characters (Fig. 120). Long, very slender with a prominent butt, approaching a length of 30 cm. in their original habitat, number of rows 10, becoming irregular at the base of the ear; distinct interlocking of the rows (Cutler, 1946); shank very long and wide, with large number of shank nodes, and large number of husks; kernels short in length, intermediate in both width and thickness, with slight striation and no imbrication;

endosperm is floury, but rather hard, white, dull, carries *du* gene, (Paul Crane, personal communication) and has high amylose content (Grobman and Swanson, 1955); aleurone colored in different shades of bronze, orange or purple; midcob color in various intensities of brown present in 70% of ears examined; glumes and lemmas colorless in 90% of ears; pericarp and cob color allelic combinations as follows: colorless-white 70.9%, brown-white ($A^{b\prime}P^{rw}$) 14.7%, orange-white (AP^{ow}) 6.7%, cherry-cherry (AP^{rr} Pl r^{ch}) 2.4%, and five other combinations (Table 6A), each lower than 2% of the total distribution.

Ears, Internal Characters (Fig. 123). Average ear diameter 30.5 mm.; cob diameter 18.8 mm.; rachis diameter 10.0 mm.; pith diameter 4.9 mm.; estimated rachilla length medium, 2.1 mm.; cob/rachis index high, 1.88; glume/kernel index high, 0.54; rachilla/kernel index medium, 0.26; lower glume long, very pubescent (highest degree of glume hairiness among Peruvian races), texture medium-hard; upper glume length medium, very strongly pubescent, texture intermediate, degree of venation low; cupules very long (the longest of all Peruvian races), and very narrow, depth intermediate; pubescence of cupules very strong (highest score among Peruvian races); height of rachis flaps intermediate; rachis induration medium; tunicate allele tu^{w} (weak tunicate); tripsacoid characters strongly exhibited.

Distribution (Fig. 119). Piricinco has been found growing in the eastern lowlands of Peru north of the Bolivian border (Department of Madre de Dios), and in the large jungle and subtropical valleys of the Urubamba, Huallaga and Ucayali river systems, which are components of the Amazon. The northernmost collections of Piricinco come from the Department of Loreto, near the source of the Amazon River. The altitude range of the typical collections of this race lies between 150 and 940 meters above sea level.

Piricinco is perhaps the most widely distributed corn race with a single continuous geographical range. From the Peruvian eastern Andean slopes it extends southwards into the Department of Pando, and adjacent continuing low areas of Bolivia, and into a large area of Brasil (Brieger *et al*, 1958). Although it has not been reported as yet from either Ecuador or Colombia, it shows its influence in several races of those countries, a fact that leads us to believe that careful searches in hitherto uncollected areas may disclose the extension of Piricinco northward.

Piricinco is grown primarily by the aboriginal tribal groups of the Amazon Basin. It is now being displaced in the new colonies of the Peruvian Montaña (jungle area) by more productive flint and dent maize types of Caribbean and Peruvian coastal origin.

Origin and Relationships. On the basis of the close similarity of average expression values of many characters, we are postulating that Piricinco arose as a hybrid race between Rabo de Zorro and Enano. Although there is not enough evidence to indicate in what geographical area the original hybridization and subsequent selection took place, it is interesting to note that Piricinco is allopatric to the present day distribution of Rabo de Zorro (excepting perhaps the La Convencion valley of Cuzco), but it is sympatric to the distribution of Enano, mostly in the Department of Pando in Bolivia, and in the Department of Madre de Dios in Peru.

Piricinco is one of the most phenotypically extreme races. It exhibits strong tripsacoid characters, such as would be expected from introgression by *Tripsacum australe*, in plant hairiness, low degree of venation of upper glume, wide shank, and rachis induration. However, some of the tripsacoid characters are offset in Piricinco by the strong influence of the Rabo de Zorro parent, one of the least tripsacoid of corn races. In some characters, such as high cob/rachis index, long glumes, long and narrow cupules, and general laxness of the ear rachis, Piricinco approaches the extreme characters of Rabo de Zorro.

Piricinco plants are low in chromosome-knob number although there are several knob positions in this race. Since Rabo de Zorro populations have a high frequency of low-knob-number plants, and Enano is derived from a low-knob-number Andean corn type, and from *Tripsacum australe*, which is in turn known to be either knobless (Graner and Addison, 1944), or has at the most a few large knobs (Ting, 1960), it may be evident why the strong tripsacoid characters of Piricinco are not accompanied by a high chromosome knob number, as is the case with the tripsacoid corn of the coast of Peru, and of corn originating in the Middle American region.

Piricinco is a stable race, and one which exhibits primitive characters. On inbreeding, no major segregations for phenotypic characters extraneous to the average racial pattern are apparent. Furthermore, Piricinco experiences only a limited degree of inbreeding depression, consistant with the assumption that this race originated early in the evolutionary development of corn in South America.

At some prior time, reverse gene flow from Piricinco into Rabo de Zorro must have occurred if we are to account for the presence of the chromosome knob positions in the latter race additional to the standard 6L and 7L positions. Morphological evidence of such reverse introgression in prehistoric times might be offered by a Mochica clay vessel molding of a Rabo de Zorro ear with imbricated kernels, long cob, and with a prominent Piricincoid butt (Fig. 33).

The ear of Piricinco has frequently 10 discernible rows in the median and upper part, a lower number than in either parent (Fig. 120). The explanation of interlocking of rows was advanced for this race by Cutler (1946) and Brieger *et al* (1958). The actual number of rows for Piricinco would be twice the apparent number as a result of rearrangement of position of spikelets and cupules if the ear were compacted longitudinally. In Piricinco ears each row of kernels is made up of kernels coming alternately from two rows of cupules, so that the number of rows of kernels and the number of rows of cupules is the same.

The extreme length of Piricinco ears may have been achieved through a genetic interaction of rachis laxness, providing intercupullary length along the row kernels, contributed by Rabo de Zorro, and an increased induration and vascularization of the cob tissues, allowing structural strength and larger intra-row kernel-number carrying capacity, as a tripsacoid character transmitted by Enano. Additionally, an independent effect due to cob elongation genes contributed by Enano, as a bridge from Tripsacum, may have also been in operation. A cob elongation effect of teosinte genes, when heterozygous, has been advanced as a hypothesis to explain the increase in length accompanying teosinte introgression in Middle American corn (Galinat *et al,* 1956).

The strongly tripsacoid characters of Piricinco parallel similar ones that appear in Middle American tripsacoid races, which received them from teosinte introgression. Since a teosinte gene flow into Piricinco has a minimum likelihood of having occurred, the tripsacoid characters of this race can perhaps best be explained by an indirect Tripsacum influence through hybridization of Enano with Rabo de Zorro, or alternatively by direct introgression into the latter race. Here we have an interesting case to demonstrate the similarity of teosinte and Tripsacum effects on corn, as well as the high probability of *Tripsacum* x *Zea* hybridization having occured directly in South America, independently of similar events occurring in Middle America. The existence of other highly tripsacoid corn races in South America, such as Chococeño, Maize Amargo, and Avati Pichinga add the weight of direct evidence to this hypothesis.

Piricinco is a variable race both in coloration of aleurone and pericarp and in length, diameter, and row number of ears. Although many of the variants described by Brieger *et al* (1958) for the Piricinco complex in Brasil may be identified in Peruvian collections, we have not felt it justifiable to subdivide this race into several, as the above mentioned authors did, at least not until additional evidence may be presented to support a case for definite racial differentiation.

Derivation of Name. Cutler (1946) first described this race in Bolivia as Coroico, the name of the locality where it was first collected. Perhaps a better name would have been Pojoso, which is the one generally assigned to this race in Bolivia.

It is interesting to note that even though it is distributed over a great area in the eastern Peruvian lowlands, this race is known even to different tribal groups by the single generalized name of Piricinco or Pirisincu (described and named as a "variety" by Herrera, 1941). We have preferred to keep this latter racial designation on account of its widespread use, rather than adhere to Cutler's chronologically earlier, but otherwise artificial name.

ANCASHINO

Plants (Fig. 127). Medium short, average height 1.38 m.; rather late, taking an average of 143 days to midsilk in plantings at Cuzco and Urubamba, under conditions similar to those of its native habitat; average number of leaves 10.5, of which 5.4 are above the ear node; leaves rather short and of medium width, with intermediate venation index; leaf area medium-low; stalk fairly thick, varying in color from dilute sun red to green; slight to no hairiness; without tillers; very susceptible to leaf rust, and

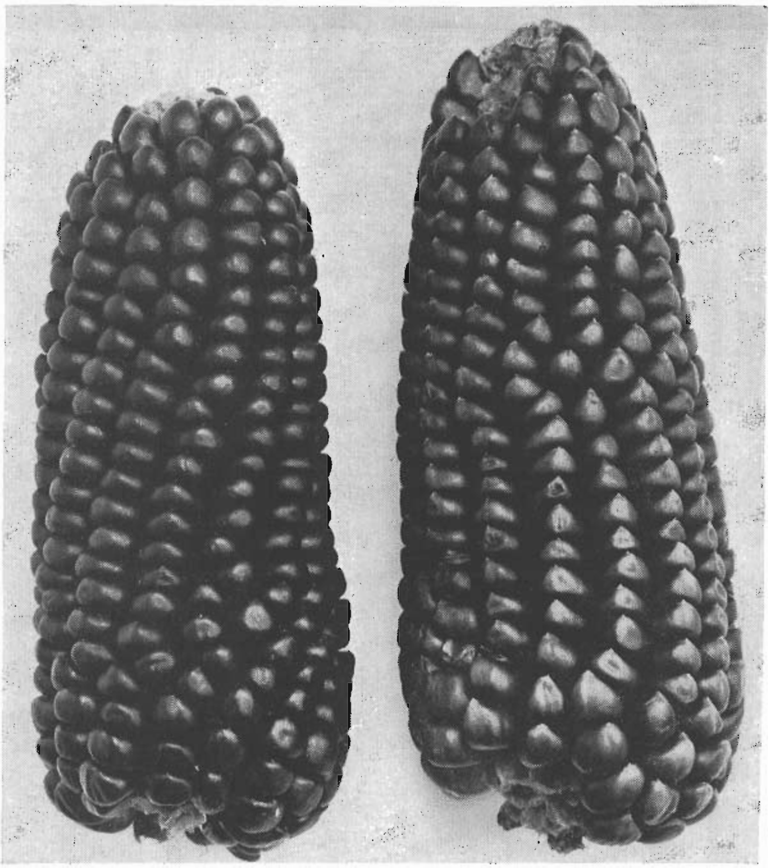


FIG. 124. Ancashino (Anc. 169, Anc. 172); typical ears. These are conical, usually with imbricated kernels, and displaying all the known array of phenotypes due to alleles at the *A* and *P* loci.

exhibiting intermediate susceptibility to Helminthosporium leaf blight; seedling color index low.

Cytological Characteristics. Small knob subterminal on long arm of chromosome 7, with a frequency of 78%; small knob subterminal on long arm of chromosome 6, with a frequency of 22%; one plant of one collection exhibited two knobs on the long arm of chromosome 6; plants with totally knobless chromosomes, with a frequency of 22%; B-chromosomes found with a frequency of 22%, varying from 3 to 4 per nucleus.

Tassel Characters (Fig. 126). Rather short tassel, short branching space which, however, comprises 42.1% of the tassel length;

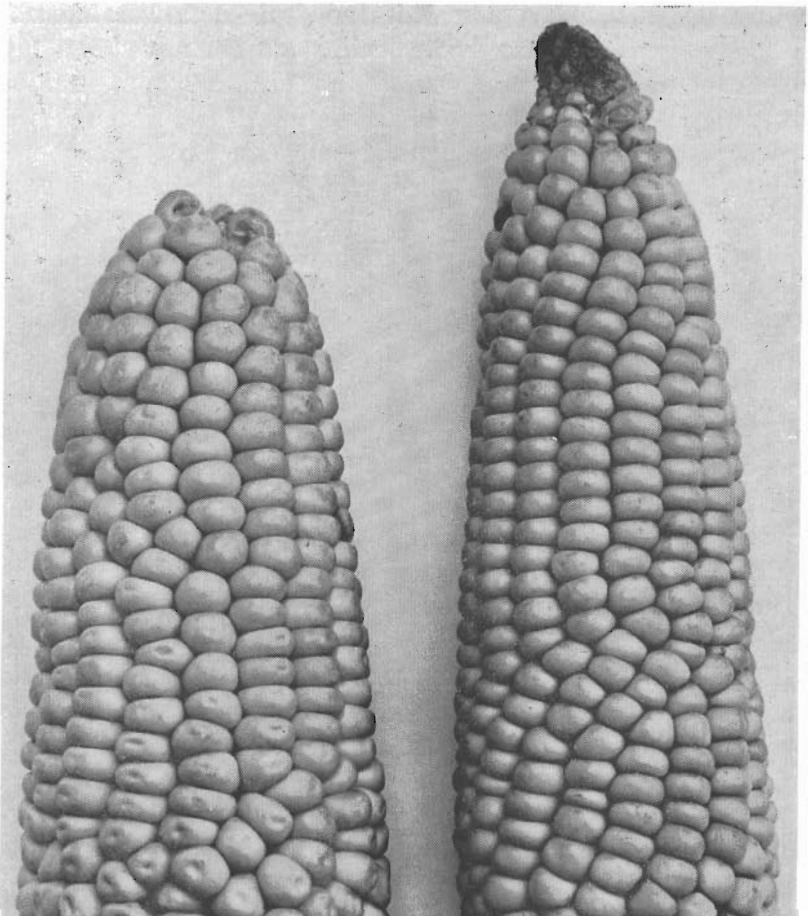


FIG. 125. Ancashino (Anc. 170). A yellowish white kernel colored selection, without imbrication.

tassel peduncle long; length and number of branches intermediate.

Ears, External Characters (Figs. 124, 125). Conical, with strong taper from base to tip, of medium length, average 13.3 cm., with an average of 13.7 rows; shank short and thin with a small number of shank nodes; few husk leaves, 6.9; kernels of medium length, with a larger than average width and thickness, varying from perfectly round to strongly beaked, and from none to a high degree of imbrication; depression and surface kernel striations absent; endosperm floury, white and very soft; midcob color present with a brownish tint in nearly 40% of ears; glume color reddish in about 40% of ears; color of lemmas absent in 60% of ears; pericarp and cob colors have the largest variability of any Peruvian race, and exhibit the highest frequencies of browns, reds and brownish reds, as here indicated: colorless-pericarp white cob 24.2%, brown-brown ($A^{b\prime}P^{rr}$) 21.8%, brownish-red-brownish red ($a^{p\prime}P^{rr}$) 11.4%, red white cap-white (AP^{cw}) 6.2%, red white cap-red (AP^{cr}) 5.9%, red-red (AP^{rr}) 5.9%, colorless-red (AP^{wr}) 3.8%, variegated red-variegated red (AP^{vv}) 4.1%, variegated brown-variegated brown ($A^{b\prime}P^{vv}$) 2.4%, and 15 other combinations in lower frequencies as shown in Table 6A.

Ears, Internal Characters (Fig. 128). Average ear diameter 49.5 mm.; cob diameter 24.5 mm.; rachis diameter 16.8 mm.; pith diameter 10.1 mm.; estimated rachilla length medium-long, 3.0 mm.; cob/rachis index small, 1.46; glume/kernel index small, 0.29; rachilla/kernel index medium, 0.23; lower glume long, hairy, of medium hardness; upper glume short, slightly hairy, intermediate texture, strong venation; cupules short, of medium width, and rather deep; rachis flaps intermediate in height; rachis induration intermediate; slight to moderately tripsacoid.

Distribution (Fig. 129). Ancashino is widely distributed in the medium-high valleys of the Department of Ancash, at altitudes from 2,700 to 3,100 meters above sea level.

Origin and Relationships. There is evidence available of the existence of Ancashino as a distinct race (Proto-Ancashino) as far back as the Classic Epoch, before 700 A.D. Ceramic replicas of ears of this race appear in the Mochica Period on the coast, (Fig. 35), and a perfect ceramic molded Ancashino ear of unknown origin is displayed in the Archaeological Museum of Huaraz, Ancash (Fig. 130).

The origin of Ancashino is apparently of greater complexity than that of the races discussed thus far. The extraordinary range of allelic combinations at the *A* and *P* loci may be held as evidence in favor of a theory of multiple hybridization, with the participation of at least three parental races.

A careful comparison of the average biometrical measurements

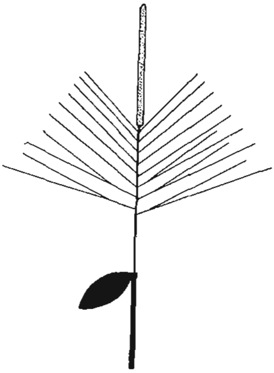


FIG. 126. Tassel diagram of Ancashino.

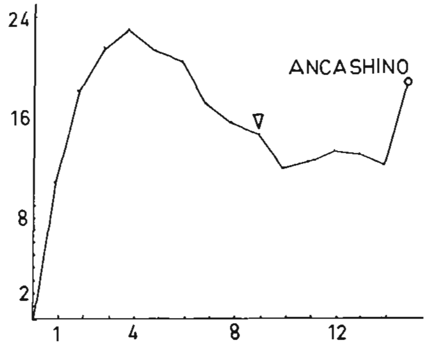


FIG. 127. Internode pattern of Ancashino.

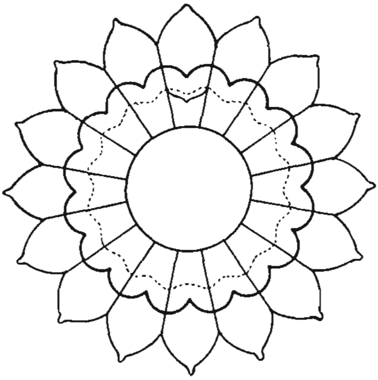


FIG. 128. Ear-cross-section diagram of Ancashino.

of the races Huayleño, Rabo de Zorro, and Confite Puntiagudo discloses a complementary similarity with most of the characters of Ancashino. Of these races, Huayleño and Ancashino are the nearest in general resemblances, as well as in the genetic structure of their respective populations with respect to the *A* and *P* loci.

Cytologically, Ancashino resembles the other three races in having knobs at the widespread normal Andean positions on chromosomes 6 and 7, and in having a relatively high frequency of plants with supernumerary or B-chromosomes. In the nine collections studied, however, no knob positions have been found in Ancashino other than those cited above, although the other races exhibit additional knobs on several positions, as indicated else-

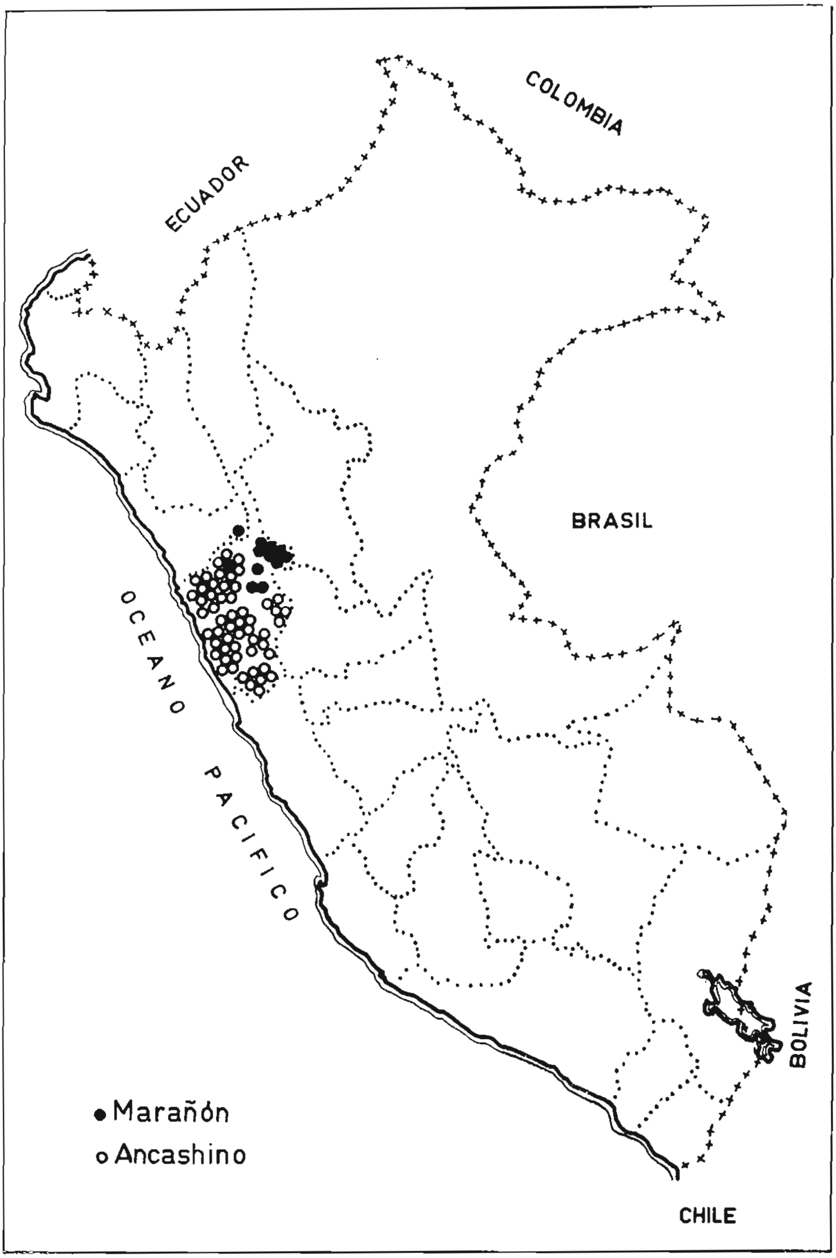


Fig. 129. Map showing the distribution of Ancashino and Marañon.

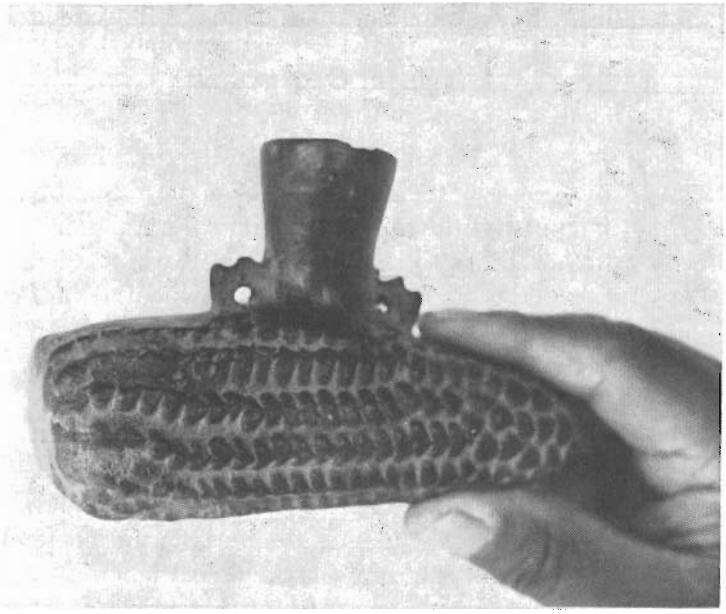


FIG. 130. Prehistoric molded ear of Ancashino (At the Museum of Huaraz).

where in this publication. If more observations should not disclose the presence of other knob positions in Ancashino, we would be forced to accept one of the following alternatives: (a) Ancashino is unrelated to the other three races, (b) Ancashino is more, or at least as primitive as the other races, and (c) additional chromosome knob positions on Rabo de Zorro, Huayleño and Confite Puntiagudo have arisen after their participation in the establishment of Ancashino as a distinct race. Other evidence, of a morphological nature, does not bear out either the first or the second of these possible explanations, leaving the third as a standing hypothesis of considerable interest. It would indicate that the original chromosome knob situation of Huayleño, Rabo de Zorro, and Confite Puntiagudo was like the one remaining in Ancashino and also in Confite Morocho—the most primitive of all these races—and the undoubted precursor of Rabo de Zorro, that is, subterminal knobs on the long arms of both chromosomes 6 and 7. Furthermore, it would indicate that Confite Chavinense, precursor of Huayleño, shared the same chromosomal condition or else lacked either or both of the above mentioned knobs.

Even though we may approach the problem of relative sequence of participation of the parental races of Ancashino by speculation, the reversal of the postulated order would have very likely brought the same end result.

It is postulated here that Rabo de Zorro hybridized with Huayleño to bring about the formation of a precursor of Ancashino, which in turn hybridized with Confite Puntiagudo to add more vigor and variability to the final race Ancashino. The original cross could well be interpreted also, as has been done before, as occurring between the predecessors of both Huayleño and Rabo de Zorro, that is, Confite Chavinense and Confite Morocho, respectively.

If this interpretation is preferred, both Huayleño and Ancashino would be postulated as sister races arising at the same time, and independently of Rabo de Zorro. The latter race and Ancashino appear simultaneously in the Mochica Period (before 700 A.D.) as molded ceramic ear replicas. This evidence alone may be used to point out their equal antiquity, but not to solve the question of priority or independence of origin.

The internode diagram pattern of Ancashino is intermediate between those of Huayleño and Confite Puntiagudo, although it does bear some general resemblance to that of Rabo de Zorro (Figs. 58, 73, 117, 127). The leaf patterns are also similar and intermediate in Ancashino between those of Huayleño on one side and Rabo de Zorro and Confite Morocho on the other. In other plant, tassel, and ear characters, Ancashino is intermediate or approaches one or another of the three parental races. The strongest argument for the participation of Confite Puntiagudo in the build-up of the composite Ancashino populations lies in its contribution to the induration of the glumes and rachis, and in the increase in diameter of the cob.

At any rate, after its origin Ancashino has experienced a two-way continuous gene exchange with Huayleño, and it has been more affected by it than Huayleño in terms of resulting overall variability, in the area of the Callejon de Huaylas or Santa river valley, where the two races are sympatrically distributed. North of the Santa valley in the Corongo area, and towards the Marañon river valley there is increasing evidence of hybridization of Ancashino and Rabo de Zorro, which in its extreme form is expressed as the distinct race Marañon.

Ancashino is the precursor of the race Shajatu, and of a possible incipient new race Sarco. It may have also had some influence on the coast on Pagaladroga (compare internode diagrams) and very likely on the race Alazan, which exhibits the widest range of pericarp and cob color alleles of any of the coastal races.

Derivation of Name. From the name of the Department of Ancash, its center of distribution.

SHAJATU

Plants (Fig. 133). Medium-short, average height 1.52 m.; late, 155 days to mid-silking in native habitat; low number of leaves, 9.5, with 5.1 of them above the ear node; length and width of leaves medium, leaf area medium, 5,167 sq. cm.; venation index high, 3.17; stalks of medium width, without tillers, and with weak prop root growth; glabrous leaf sheaths; plant color dilute sun red; ear borne on eighth node, at an average height of 0.80 m. from the ground; susceptible to both rust and Helminthosporium.

Cytological Characteristics. One medium to small knob subterminal on chromosome 7L, with a frequency of 87.5%, and one small knob subterminal on chromosome 6L, with a frequency of 12.5%; one plant in eight had B-chromosomes, 3 in number, the rest did not.

Tassels (Fig. 132). Medium-long peduncle; long tassel, with large branching space, 16.9 cm., and comprising 46.4% of tassel length with long branches, relatively large number of primaries, very large number of secondaries and medium number of tertiaries.

Ears, External Characters (Fig. 131). Conical, with smooth tapering toward the tip, length medium-short, averaging 10.3 cm.; mean row number 16.3; shank length medium, diameter small, number of nodes medium, number of husks medium; kernels medium in all dimensions, non-imbricated, without striations; endosperm white, floury and very soft, with purple aleurone (mostly *Pr*) strongly selected for giving a particularly characteristic ear appearance to this race; this character is present with the highest frequency of any Peruvian race, and the majority of ears of Shajatu are pure for this character; midcob color brownish in 50% of ears, both glumes and lemmas colored red in ⅔ of ears examined; pericarp and cob color allelic frequencies, as follows:

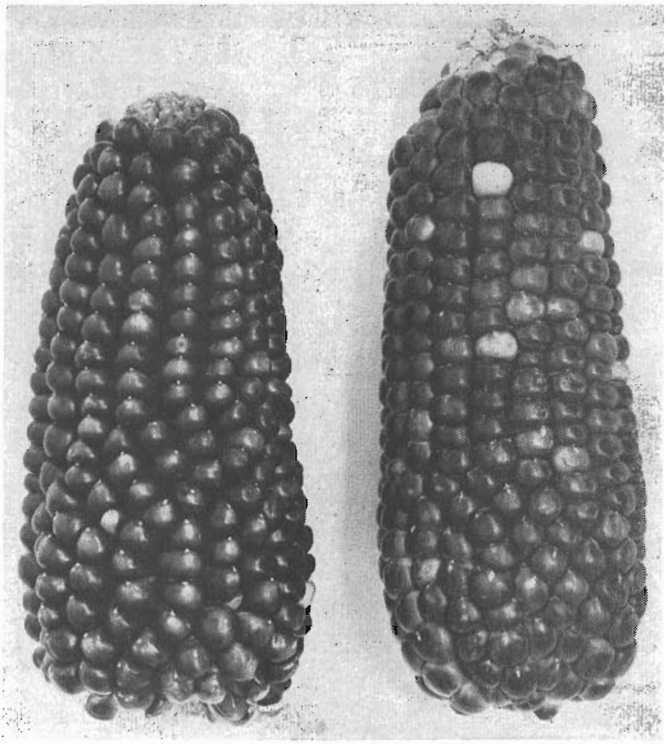


FIG. 131. Shajatu (Anc. 117). The ears of Shajatu exhibit a characteristic purple aleurone color.

colorless-white 74.3%, light brown-light brown ($A^{b'}P^{rr}$) 10.2%, colorless-red (AP^{wr}) 7.7%; red-red (AP^{rr}) 5.1%; and red white cap-red (AP^{cr}) 2.6%.

Ears, Internal Characters (Fig. 134). Average ear diameter 44.0 mm.; cob diameter 25.6 mm.; rachis diameter 14.9 mm.; pith diameter 6.1 mm.; estimated rachilla length medium, 2.5 mm.; cob/rachis index medium, 1.72; glume/kernel index low, 0.45; rachilla/kernel index medium, 0.21; lower glume length intermediate, pubescence slight, texture horny; upper glume length medium-long, pubescence slight, texture intermediate, venation score low; cupules of medium length, width, and thickness, hairiness medium to strong; rachis flaps low in height; rachis induration medium to low; tripsacoid characters very weak.

Distribution (Fig. 89). Shajatu is restricted to the northern region of the Department of Ancash, north of the bend of the

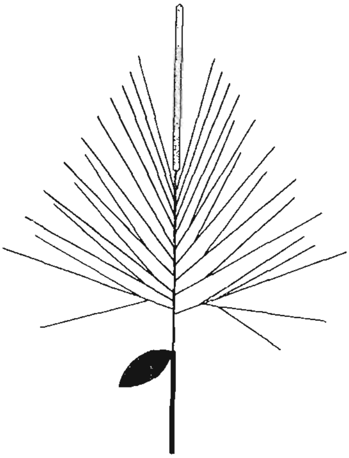


FIG. 132. Tassel diagram of Shajatu.

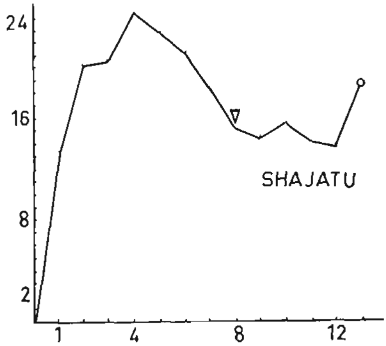


FIG. 133. Internode pattern of Shajatu.

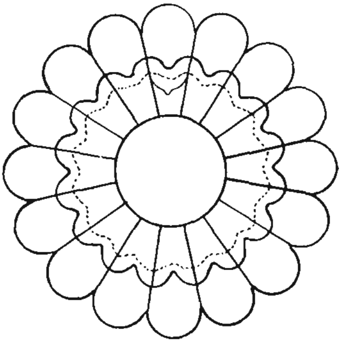


FIG. 134. Ear-cross-section diagram of Shajatu.

Santa River. It is abundantly represented in collections originating between the localities of Corongo and Pallasca. The influence of this race on the race Marañon is evident in the Marañon valley in the Departments of Ancash and La Libertad.

Shajatu is grown at middle altitudes ranging from 2,300 to 2,800 meters above sea level.

Origin and Relationships. Shajatu is evidently very closely related to Ancashino, from which it probably originated by selection for the purple aleurone character. Such selection reduced the variability originally present in Ancashino, as may be inferred from a comparison of the range of phenotypes of pericarp and cob colors of both races (Table 6A).

The relative proximity of these two races may be further demonstrated by similarity of cytological features, internode pattern (Figs. 127 and 133), leaf pattern indices, internal ear characters (Figs. 128 and 134) and general statistics for various morphological characters (Tables 2A to 5A and 8A).

Although Shajatu is a secondarily derived race, it may have played an important role in the formation of the race Marañon, and also in the origin of the coastal race Jora.

Derivation of Name. The common name applied to the race in northern Ancash has been adopted.

ALAZAN

Plants (Fig. 137). Tall, average height 2.14 meters, although certain collections have consistently shorter plants; medium maturity, 93 days to mid-silking at La Molina, which is reduced by about two weeks in its native habitat; number of leaves large, 12.7; with an average of 4.9 leaves above the ear node; leaves long and narrow with intermediate venation index, 2.7, leaf area intermediate, 5,700 sq. cm.; ear located on the eighth node above ground, fairly high at 1.38 meters; stalk intermediate in width; tillers seldom present, and then, short; pubescence of leaf sheath slight; plant color most frequently green; resistant to both leaf rust and Helminthosporium.

Cytological Characteristics. Alazan is one of the races with the highest number of chromosome knobs, ranging from 9-14 per nucleus. It has 23 to 24 knob positions. The distribution of these knobs is as follows: chromosome 1S, subterminal, frequency 77.7%; 1L subterminal 20%; 2S subterminal 20%; 2L subterminal 83.3%; 3S terminal 28.5%; 3L terminal 20%, subterminal 87.5% (large knobs); presence of two simultaneous knobs subterminal in 3L, 12.5%; 4S terminal 20%, subterminal 40%; 4L subterminal 87.5%; 5S subterminal 42.8%; 5L subterminal 40%; 6L subterminal 90%, two knobs subterminal in 6L, 40%; 7S terminal 75%; 7L subterminal 100% (large knobs); 8S terminal 33%; 8L terminal 20%, subterminal 80%; 9S terminal 85.7%; 9L subterminal 77.8%, two knobs subterminal in 9L, 11%; 10L, terminal 11% (possibly abnormal 10). The most frequent knob class is 10 knobs per cell. Of all examined samples 68% had knob and

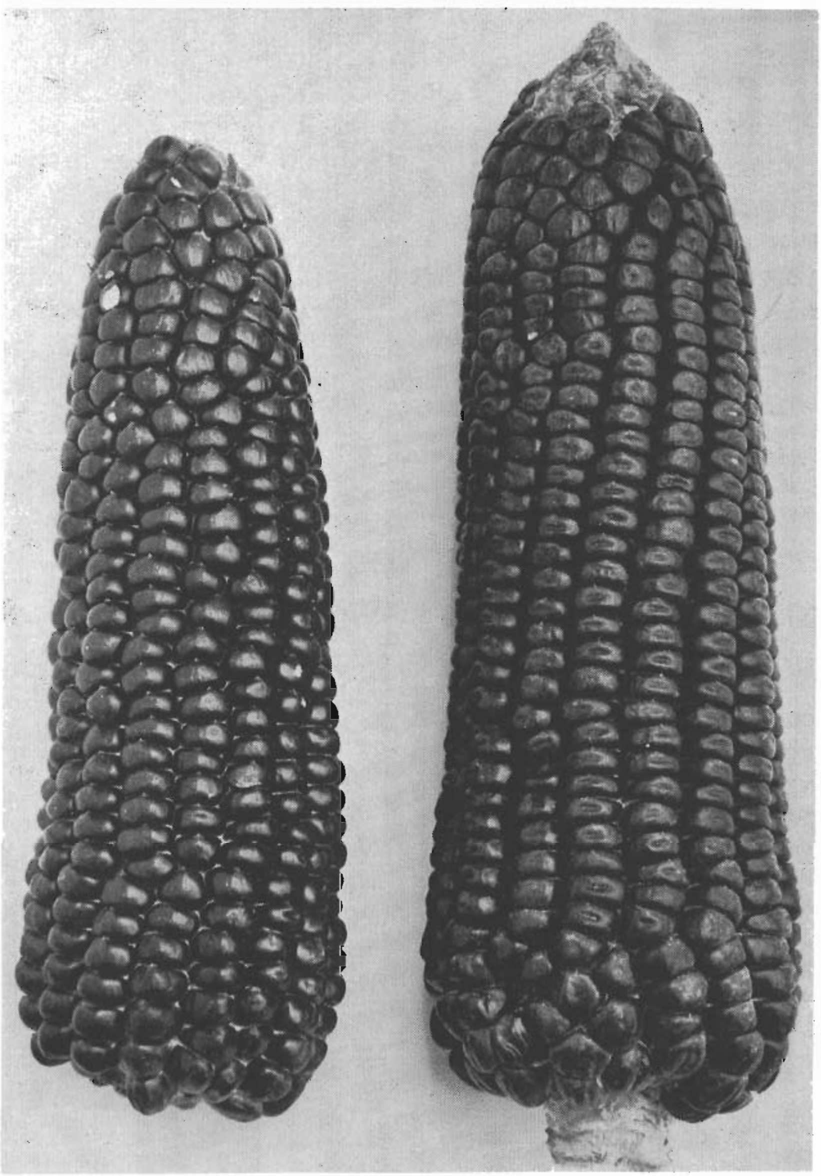


FIG. 135. Alazan (Lib. 22), typical ears. This is a highly tripsacoid race from the North Coast, with red pericarp color used for making *chicha* (corn beer).

centromere fusions. B-chromosomes were present in number of 1 per cell in only one plant in one collection out of 14 collections studied.

Tassel (Fig. 136). Peduncle short, tassel length fairly large, branching space long, 16.6 cm. and comprising 44.9% of the tassel; long branches, very high number of primary and secondary and high number of tertiary branches; condensation index among highest of Peruvian races, 1.10.

Ears, External Characters (Fig. 135). Cylindrical to slightly conical, medium-long, with slight taper toward the tip, often fasciated, and occasionally very broad; most frequent number of rows is 14; this race attains, however, the highest row number among coastal Peruvian races, reaching up to 28 rows; shank length and diameter intermediate, with a large number of nodes; large number of husks; kernels of medium length, width, and thickness; imbrication normally absent, although it appears to a slight degree in some collections which have strong Sierra influence; kernel striation strong, slight to medium denting; endosperm floury, fairly soft and white, midcob color absent in 84% of ears; color of glumes and lemmas red in 92% of ears; pericarp and cob color allelic combination as follows: red-red (AP^{rr}) 57.6%, red white cap-white (AP^{cw}) 16.5%, brown-brown ($A^{b\prime}P^{rr}$) 8.2%, red white cap-red (AP^{cr}) 3.5%, brown-white ($A^{b\prime}P^{rw}$) 3.5%, brown white cap-white ($A^{b\prime}P^{cw}$) 3.5%, colorless-white 3.5%, and three other combinations (Table 6A) with 1.2% each.

Ears, Internal Characters (Fig. 138). Average ear diameter 42.8 mm.; cob diameter 30.2 mm.; rachis diameter 14.5 mm.; pith diameter 10.3 mm.; estimated rachilla length short, 1.0 mm.; cob/rachis index medium-low, 1.56; glume/kernel index medium, 0.50; rachilla/kernel index low, 0.09; lower glume long, with medium hairiness and fairly hard; upper glume long, weakly hairy, of intermediate hardness, and medium venation; cupules long, wide, and very deep; hairiness of cupules very weak; height of rachis flaps low, rachis tissue induration medium; tunicate alleles *tu* and tu^{w} (weak tunicate, as defined by Mangelsdorf, 1948); tripsacoid characters are variable, but frequently strongly exhibited in plants of this race.

Distribution (Fig. 109). Alazan is the corn race chiefly preferred for the manufacture of *chicha* on the North Coast; its red pericarp has been selected for the purpose of giving a rich deep

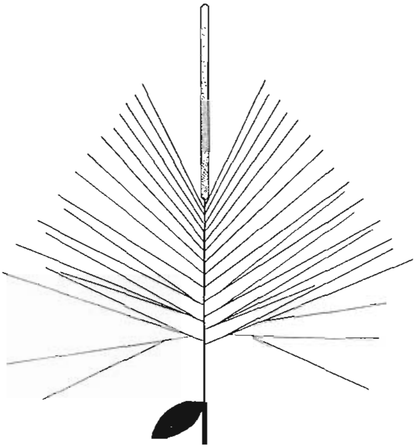


FIG. 136. Tassel diagram of Alazan.

FIG. 137. Internode pattern of Alazan.

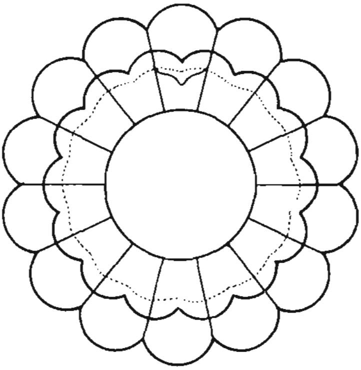


FIG. 138. Ear-cross-section diagram of Alazan.

brownish tint to the brew which in that region is called *claro* (Nicholson, 1960). It is grown in all the valleys of the Department of La Libertad, from Chao northwards, and also in the Departments of Lambayeque and Piura, and has been grown there since the Mochica Period. A large concentration of Alazan is found in the relatively dry valleys of the North Coast and in marginal areas poor in water supply, where crops of a higher economic value, and more water demanding, such as rice, sugar cane, and cotton, cannot be grown. In the valleys with a large water supply, Alazan is grown, if at all, as a filler crop to utilize the poor soils in marginal areas or as a second rotation crop. It is lower in production than the coastal flint varieties or Arizona, under an adequate water supply. It is more drought resistant then they, but not as resistant as Mochero. One to two flooding irrigations are sufficient to carry a field of Alazan to maturity, aided by the circumstance that the northern coastal valley soil types are deep and have a high clay and silt content.

The range of altitude where collections of Alazan have been made is from 15 to 100 meters above sea level.

Origin and Relationships. Prehistoric ears and molded clay pottery from the North Coast provide evidence of the coexistence in that general area of a Proto form of Alazan together with the ancestral forms of Mochero, and Pagaladroga (Figs. 29 and 30), at least as far back as the Classic Epoch (0-500 A.D.).

The Mochicas cultivated a Proto-form of Alazan with rather short, cylindrical ears, and with 10 rows of kernels. There may be little doubt that archaeological Proto-Alazan, since it is intermediate in ear characters between its two other sympatrically distributed races (Table 1A) Proto-Mochero and Proto-Pagaladroga, was the evolutionary product of early hybridization between them. These intermediate characteristics are still apparent in present day Alazan, and may be appreciated by referring to Figs. 103, 108 and 138 of ear-cross-section diagrams, Figs. 101, 106 and 136 of tassel diagrams, leaf pattern indices, and Figs. 102, 107 and 137 of internode diagrams.

There is, however, an added complexity in populations of Alazan which is indicative of the creation of an expanded genetic pool of variability in this race as the result of gene flow from other races. The strong tripsacoid characters exhibited by many plants of Alazan may very well have originated from Chococeño a highly tripsacoid race whose direct influence diffuses out of the Pacific lowlands of Colombia into Ecuador and the northern coast of Peru. Corn collections from Tumbes, on the northern boundary of Peru, recognized as the incipient race, Tumbesino, show a strong influence of Chococeño. The same influence, but more moderate in extent, has been observed in ears of Mochero which exhibit some bronze and orange aleurone phenotypes found in the race Chococeño in Ecuador and on the Pacific coast of Colombia. These colors would be easier to identify in Mochero than in Alazan, since the former lacks the red pericarp of the latter race.

Chococeño very likely is a northern derivative of Confite Iqueño modified by Tripsacum introgression in Colombia (Roberts *et al,* 1957). It shares, therefore, a partially common genetic background with Mochero, but is later and more vigorous than the latter in growth habit. Alazan has inherited several peculiar characteristics from Chococeño, including taller plants, ears with larger number of rows, such rows being characteristically compacted and tight-fitting, and large number of chromosome knobs.

Through Alazan, as a bridge race, the tripsacoid characters of Chococeño have extended further down the Peruvian Coast and have strongly influenced the ear phenotype of the flint race Perla.

Adding to the genetic complexity of Alazan, it has experienced within the last 20 years very strong hybridization with Arizona, a race of the Tuxpeño complex introduced by the Ministry of Agriculture of Peru into the North Coast. In most areas it is now difficult to find Alazan ears which do not show a variable amount of contamination with Arizona. In the valleys of Viru and Moche the continuous associated growth of both Alazan and Arizona has resulted in segregating populations of red and colorless pericarp plants, which are strongly selected for ear type to conform to the more cylindrical Arizona extreme, while maintaining the desirable red pericarp color of Alazan. These populations constitute the incipient stage of a new race, which we are designating with the general name of Colorado.

Derivation of Name. Alazan is a name of Spanish origin which on the Peruvian coast is applied to the dark and dull reddish coloration of the hair of criolle horses, and by analogy to coastal red corn, in general. In the larger Alazan growing areas there is a more restricted application of the name to ears showing a red-white cap pericarp usually overlying an orange-yellow aleurone.

SABANERO

Plants (Fig. 141). Tall, average height 2.30 m.; late, averaging 151 days to mid-silk at 2,800 meters in the Urubamba valley, number of leaves large, averaging 12.3, of medium length and width; leaf pattern index high in Quadrant II, 74%, zero value in Quadrants I and III; venation index low, 2.5; leaf area intermediate, 4,890 sq. cm.; number of leaves above the ear 4.5; ear

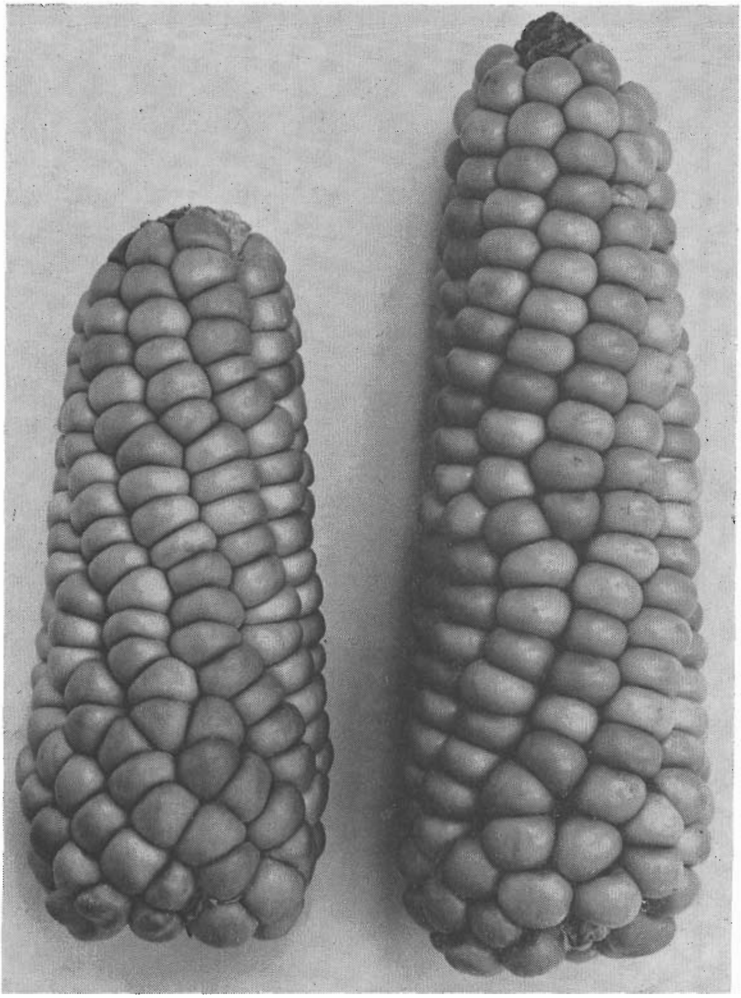


FIG. 139. Sabanero (Caj. 69, and Caj. 43), typical ears. This race is derived from Morocho, and it in turn has been the parent of some races in Colombia.

implanted on the seventh node at an average height of 1.74 m.; stalk diameter medium-large; no tillers present; hairiness lacking; plant color sun red; intermediate resistance to Helminthosporium and rust; seedling color index low.

Tassels (Fig. 140). Peduncle short, tassel intermediate in length; branching space large, 16.3 cm., and 47.8% of tassel length; length of branches short; number of primary branches inter-

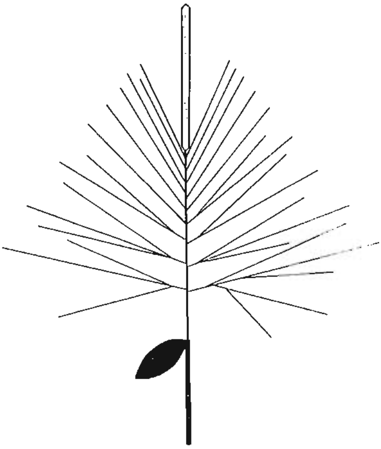


FIG. 140. Tassel diagram of Sabanero.

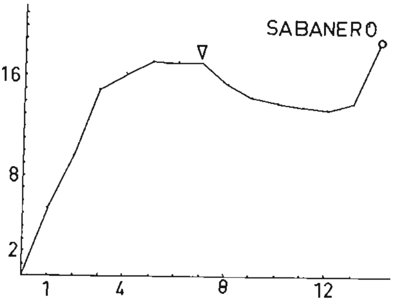


FIG. 141. Internode pattern of Sabanero.

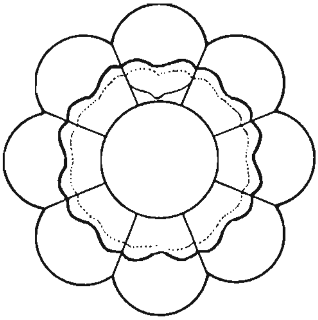


FIG. 142. Ear-cross-section diagram of Sabanero.

mediate, secondary branches intermediate, and tertiary branches low; condensation index low, 1.00.

Ears, External Characters (Fig. 139). Medium-long, middle section fairly cylindrical with a slight taper to the tip, and a conspicuous bulky butt; average number of rows 10.1 tending to an irregular kernel arrangement especially at the base of the ear; shank short and very wide, with a small number of nodes; number of husks intermediate; kernels short, wide, extremely thick, rounded, lacking imbrication, denting and striation; endosperm mostly white, floury, and soft, with no aleurone colors in the Peruvian collections; red midcob color, present in 40% of ears;

glumes and lemmas colorless on all ears examined; pericarp and cob color allele combination frequencies: colorless-white 79.4%, colorless-red (AP^{wr}) 8.8%, and four other classes with less than 3% each (Table 6A).

Ears, Internal Characters (Fig. 142). Average ear diameter 42.2 mm.; cob diameter 23.2 mm.; rachis diameter 16.6 mm.; pith diameter 7.6 mm.; estimated rachilla length short, 0.6 mm.; low cob/rachis index, 1.53; low glume/kernel index, 0.26; low rachilla/kernel index, 0.05; lower glume short, sparsely pubescent, and rather horny; upper glume short with very light hairiness, relatively hard texture, and medium-strong degree of venation; cupules narrow, very wide and deep, with moderate pubescence; rachis flaps very short; rachis induration slight; expression of tripsacoid characters intermediate to low.

Distribution (Fig. 94). Sabanero is grown at intermediate altitudes around 2,500 meters in the Department of Cajamarca. In populations more or less mixed with other races, Sabanero extends into the southern part of the Department of Amazonas and into the Sierra of La Libertad and northern Ancash. Especially in Cajamarca, its distribution is sympatric to those of the related races, Morocho, Cajabambino and Cuzco. Outside of Peru it occurs in Ecuador, Colombia, and Venezuela.

Origin and Relationships. A close comparison of ear characters between Sabanero and Morocho leaves little doubt, if any, that these two races are closely related, and that Sabanero originated from Morocho.

The former race is extreme in certain ear characters, such as width of cupule, small rachilla and glume length, the low values of the glume/kernel and rachilla/kernel indices and the large size, particularly thickness, of the kernel. These characters approach those of Cuzco and its related races, such as Uchuquilla, and this fact suggests that there has been a continued exchange of genes between the two groups of races in the Cajamarca region. This hybridization may have been initiated with the introduction of Cuzco maize into the areas from Cajamarca to Quito in the later periods of the Inca Empire. Cuzco maize is even today widely grown in Cajamarca, which is its most important secondary center of distribution.

It appears likely that Sabanero has also experienced hybridization with Piricinco. The bizarre aleurone colors of the latter have, however, been selected out in Peru, but they are more prevalent in Sabanero from Colombia.

Further hybridization with other sympatrically distributed races, which had reciprocal genetic influence with Sabanero, such as Morocho Cajabambino, grown from Chachapoyas to Cajabamba, modified the plant type of Sabanero to make it conform to the general pattern of northeastern tropical races, such as Rabo de Zorro, Piricinco, Morocho Cajabambino and Marañon.

Sabanero has been the parent of a number of races to the north of Peru: Montaña, Cacao, Cubuya, and its derived races in Colombia, and further derivatives in Central America (Fig. 239). It does not seem to have influenced the maize south of Cajamarca.

Derivation of Name. Priority is accepted for the name Sabanero, as given to this race in Colombia by Roberts *et al* (1957), considering, further, that no generalized name has been found designating this race in Peru.

UCHUQUILLA

Plants (Fig. 44). Short, average height 1.33 m., of intermediate maturity, 129 days to mid-silking at 3,200 meters; low number of leaves, short and narrow, venation index very high, 3.98; stalk of small diameter, without tillers; plant color sun red; susceptible to rust and to Helminthosporium leaf blight.

Tassel (Fig. 144). Peduncle long; large, total tassel length 40.5 cm.; branching space large, 16.5 cm. and 40.7%; branches long, and in intermediate numbers.

Ears, External Characters (Fig. 143). Cylindrical, average length 16.7 cm., with very slight taper towards both tip and base; average number of rows 9.5; shank very long and narrow, with fairly large number of nodes; large number of husk leaves, 9.5; kernels of medium length, width and thickness, not imbricated, with slight dent and medium striation; endosperm yellow to orange in the external cell layers, flinty with soft starchy center; overall kernel hardness intermediate; midcob color absent in 90% of ears; lemmas and glumes red in 80% of ears; pericarp and cob color combinations: colorless-white, 38.5%, orange-white (AP^{ow}) 23.1%, orange-purple ($AP^{or}Pl$) 23.1%, orange-red ($AP^{or} P^{rr}$) 7.7%, colorless-red (AP^{wr}) 7.7%.

Ears, Internal Characters (Fig. 145). Average ear diameter 33.8 mm.; cob diameter 18.6 mm.; rachis diameter 11.3 mm.; pith

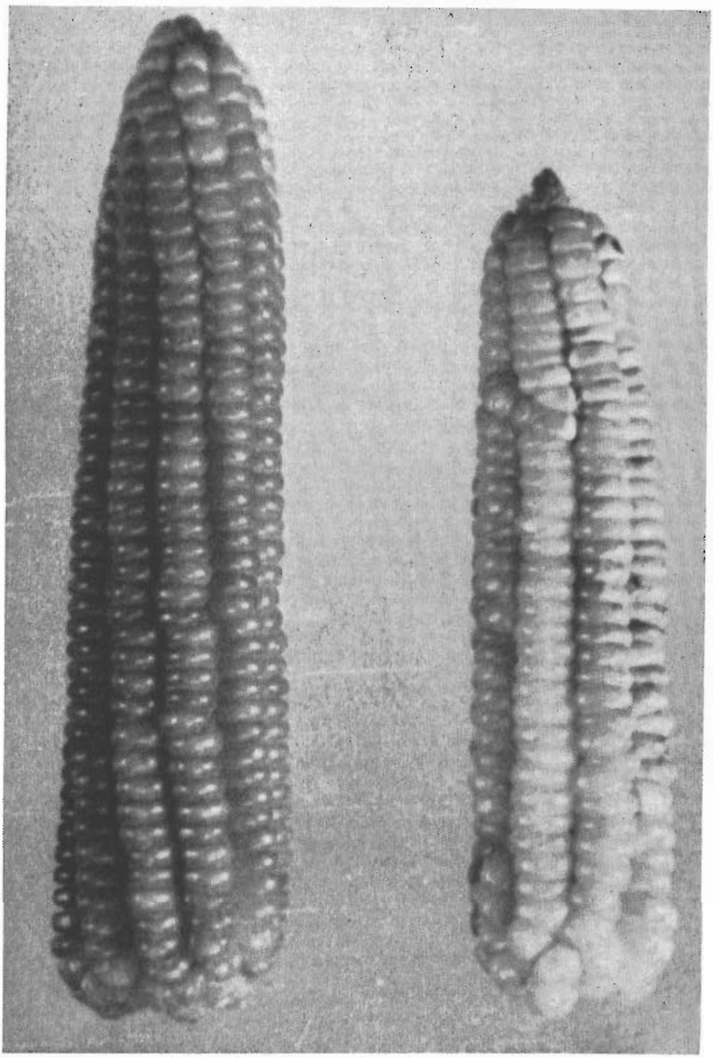


FIG. 143. Uchuquilla, typical ears.

diameter 4.7 mm.; estimated rachilla length very short, 0.3 mm.; cob/rachis index medium, 1.64; glume/kernel index low, 0.33; rachilla/kernel index very low, 0.03; lower glume very short with medium pubescence, and horny; upper glume short, weakly pubescent, fairly hard, and moderately veined; cupules short, wide, and shallow, with abundant hairs; rachis flaps very low, their height being the lowest of all Peruvian races; intermediate

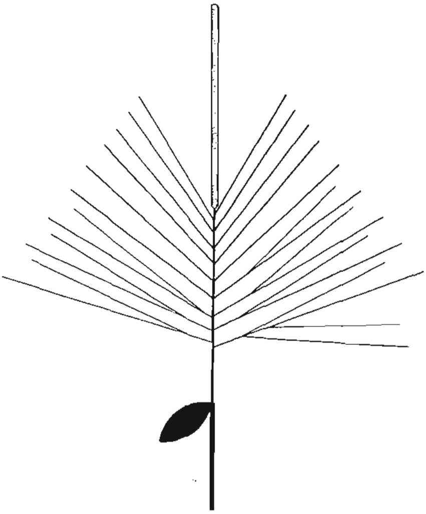


FIG. 144. Tassel diagram of Uchuquilla.

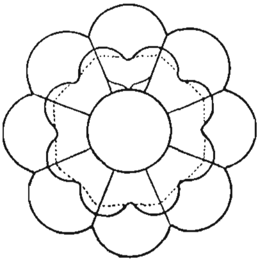


FIG. 145. Ear-cross-section diagram of Uchuquilla.

degree of rachis induration; tripsacoid characters exhibited to a moderate extent.

Distribution (Fig. 114). The area of dispersal of this race extends beyond the boundaries of Peru, with its highest concentration undoubtedly in Bolivia. In Peru it is found in the Department of Puno and to a very limited extent in Cuzco. This race is grown in Puno at altitudes from 2,000 to 2,500 meters.

Origin and Relationships. Uchuquilla has probably played an important role in the origin of the Cuzco group of races. In its typical form, more often found in Bolivia, Uchuquilla differs from Cuzco in having more slender, cylindrical ears without approaching the semi-globose or middle ear thickening of ears of many highland Peruvian races.

There is little doubt that Uchuquilla originated from a popcorn-like race, Kcarapampa, which possesses the same ear characteristics as the derived race: 8-row cylindrical ears, but of very small dimensions, with orange pericarp color, Kcarapampa is concentrated mostly in southern Bolivia in the Department of Tarija (Ramirez *et al,* 1960). Direct Tripsacum introgression into Kcarapampa or else hybridization of the latter with some tripsacoid race are suggested as alternative hypotheses to explain the origin of Uchuquilla, and its tripsacoid characters.

Kcarapampa could well be one of the ancestral popcorn races derived from Confite Morocho, and might once have had a wider geographical distribution than today. A pottery molding which closely resembles an ear of Kcarapampa is shown in Fig. 38, from a vase of the Inca Period of the North Coast.

Derivation of Name. From the common name given to the race in Bolivia, and used as far north as the valley of Urubamba, Cuzco, Peru. It is referred to as Uchucullo by Herrera (1941).

CUZCO CRISTALINO AMARILLO

Plants (Fig. 148). Short, average height 1.57 m., fairly early, averaging 133 days to mid-silk at 3,200 meters above sea level in Cuzco; average number of leaves 11.3, leaves intermediate in length, and relatively wide, with an intermediate venation index, 2.8; leaf area rather small, averaging 4,246 sq. cm.; ear located on the 3rd to 5th node at a height of 0.73 m. above ground and with 5.9 leaves above the ear node; stalk width intermediate; no tillers present; pubescence slight; plant color sun red; intermediate resistance to rust and Helminthosporium blight.

Cytological Characteristics. Only two plants were examined; one was knobless, while the other had one small knob subterminal on 7L and one small terminal knob on chromosome 9S. Neither plant had B-chromosomes.

Tassel (Fig. 147). Peduncle long; tassel length intermediate; branching space intermediate in length, 13.9 cm., but large proportionally to the total tassel length, 45.1%; length of branches intermediate; number of primary and secondary branches low, tertiary branches absent; condensation index low, 1.00.

Ears, External Characters (Fig. 146). Cylindrical with elliptical outline; smooth gradual taper towards both tip and base; length medium short; average number of kernel rows 8.4; relatively long shank, of small width, medium-small number of nodes; number of husks intermediate, 8.6; length of kernels medium-long, width large, thickness intermediate; kernel imbrication none, striation and denting slight; endosperm more or less flinty to a varying depth, with a central soft starchy core, the higher altitude collections being more flinty; endosperm color yellow; aleurone colorless; midcob color absent in all ears examined; glume and lemma color red in 62.5% of ears; pericarp and cob color combinations

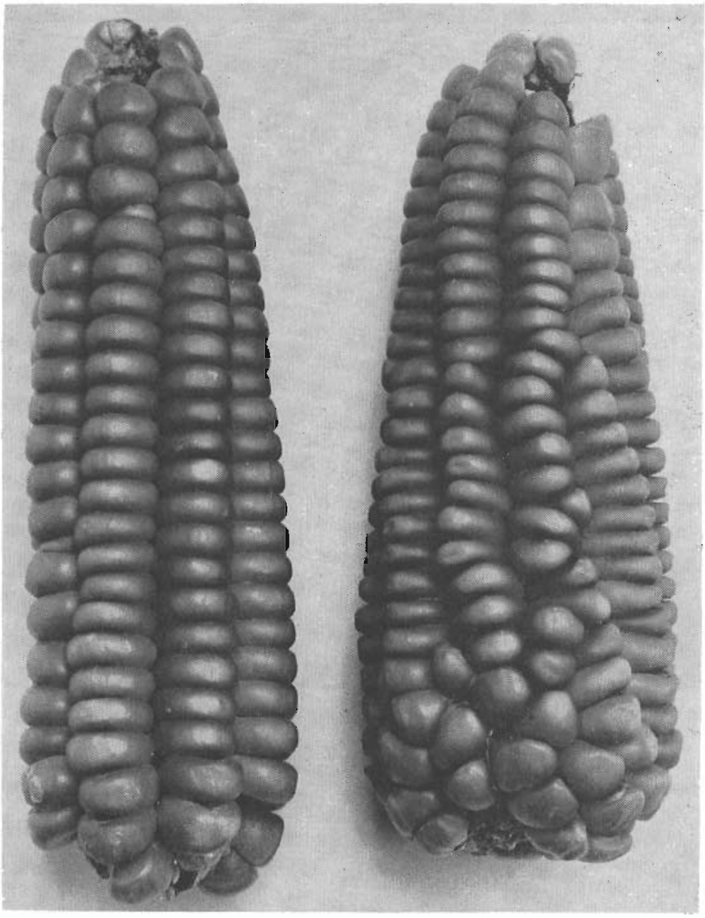


FIG. 146. Cuzco Cristalino Amarillo (Cuz. 61); typical ears.

as follows: colorless-red (AP^{wr}) 45.8%, colorless-white 23.9%, brown-brown ($A^{b'}P^{rr}$) 12.5%, red-red (AP^{rr}) 5.5%, red white cap-red (AP^{cr}) 5.5%, and 13 other combinations each with a frequency of 3.5% or lower.

Ears, Internal Characters (Fig. 149). Average ear diameter 40.1 mm.; cob diameter 18.8 mm.; rachis diameter 12.8 mm.; pith diameter 7.0 mm.; estimated rachilla length medium, 2.2 mm.; cob/rachis index low, 1.52; glume/kernel index low, 0.29; rachilla/kernel index medium-low, 0.19; lower glume length medium-short, with intermediate hairiness, and intermediate induration; upper glume length short, slightly pubescent with relatively hard texture

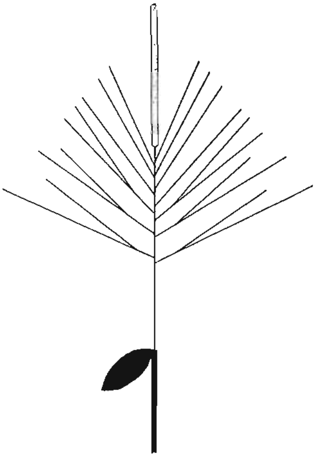


FIG. 147. Tassel diagram of Cuzco Cristalino Amarillo.

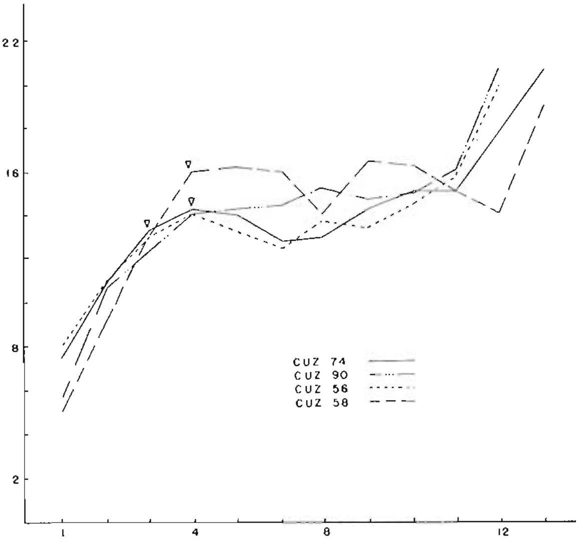


FIG. 148. Internode patterns of four collections of Cuzco Cristalino Amarillo grown in Cuzco in 1958, illustrating the extent of variation encountered in typical collections of this race.

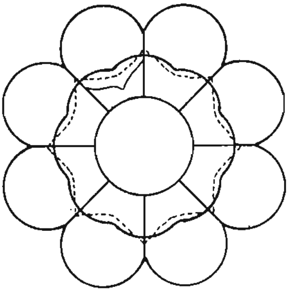


FIG. 149. Ear-cross-section diagram of Cuzco Cristalino Amarillo.

and very strong venation; cupules medium in length and width and rather shallow in depth; cupule hairiness profuse; height of rachis flaps short; rachis induration intermediate; tunicate allele *tu;* tripsacoid characters apparent to a very limited extent.

Distribution (Fig. 94). Cuzco Cristalino Amarillo occurs in the irrigated valleys of the southern Andean highlands with centers in the Cuzco and Vilcanota areas of the Department of Cuzco and in the Abancay, Chalhuanca and Andahuaylas regions of the neighboring Department of Apurimac. It extends northwards into the lower part of the Mantaro valley in Huancavelica and the southernmost part of this valley in Junin and southwards toward the Department of Puno. This race intergrades with Uchuquilla or a yellow form of Huancavelicano, with ears distinctly star-shaped, when viewed in cross-section (on account of deep-cleavage furrows between the 8 rows of very large kernels of the ears of these races).

In Cuzco this race is grown as a relatively smaller seeded, flintier and earlier sub-race at altitudes of 3,000 to 3,500 meters along all the Abancay-Cuzco-Sicuani highway. In the Urubamba (Vilcanota) valley, Cuzco Cristalino Amarillo approaches very closely the larger plant, ear, and kernel sizes of Cuzco Gigante. The yellow 8-row semi-flinty corn of this valley is probably intermediate, through hybridization, between modern selected Cuzco Gigante and Cuzco Cristalino Amarillo from higher altitudes. Considerable segregation of floury and semiflinty types could still be observed in 1953 and in later years in ears of hybrid populations drying after harvest, north of Ollantaytambo in the Urubamba valley.

This sub-race is known as Amarillo Urquillos (in the Urquillos area of the Vilcanota valley) and is the highest yielding variety of the race. Within the Vilcanota valley it is grown from Ollantaytambo a few miles towards the north, also in the Huayllabamba-Urquillos area. It is alternated with Cuzco Gigante from Calca to Pisac, at an average altitude of 2,800 meters.

A very early sub-race of Cuzco Cristalino Amarillo, Maras maize, growing at the great altitude of 3,500 meters in the Maras district between Cuzco and Urubamba is extreme in earliness, drought resistance, and shortness of stalk height.

Origin and Relationships. Cuzco Cristalino Amarillo is probably a hybrid race originating from the cross of Uchuquilla with a Huancavelicano flinty sub-race. We may well conceive how a flinty form of Huancavelicano evolving from Confite Morocho could have been one of the parents of Cuzco Cristalino Amarillo. Such large kernelled unimbricated collections of flinty 8-rowed corn such as the ear shown at the left in Fig. 95, have been found in Confite Morocho (Collection Aya. 20).

Cuzco Cristalino Amarillo ears are shorter, more nearly elliptical, have larger kernels, fewer in number in the row than Uchuquilla, but the ears are larger than those of Huancavelicano and conform more to the general morphology of the latter. There is a marked tendency toward the slight imbrication and beaked kernels shown by the high altitude race Huancavelicano, in high altitude collections of Cuzco Cristalino Amarillo.

In postulating this manner of origin of Cuzco Cristalino Amarillo we are in keeping with a hypothesis of gradual parallel evolution of maize races starting from an early level made up exclusively of popcorn races. It may be conceived that the primitive popcorn races hybridized among themselves as it may also be conceived that races directly derived from each popcorn in their turn hybridized again to form new races. Since Cuzco Cristalino Amarillo fits better as a hybrid race between Uchuquilla and Huancavelicano on the basis of ear morphology (Figs. 95, 143, 146), geographical distribution (Figs. 94, 99, 114), plant (Figs. 44, 97, 148) and other characters (Table 13) than between the far more removed ancestors Confite Morocho and Kcarapampa, we prefer to adopt the hypothesis that Cuzco Cristalino Amarillo is the product of the hybridization of the derived races rather than of the popcorns themselves.

Undoubtedly Uchuquilla has received considerable reverse transmission of Cuzco Cristalino Amarillo germplasm, but not enough to blend to homogeneity the differences between both races. Plant internode patterns characteristic of these two races are similar (Compare Figs. 44, 148, and also with Fig. 49 of Brieger *et al* (1958) for Amarillo de Ocho), but plant, and leaf size, ear shape and gene frequencies, as evidenced by differences in the *A* and *P* gene systems, are conspicuously different. The two discrepant internode patterns for Uchuquilla presented by Brieger *et al* (1958) in their Fig. 49 and by Ramirez *et al* (1960) in their Fig. 62, can be reproduced in the same collections of Uchuquilla when grown in different locations and seasons, as is shown in our Fig. 44. It may be well to indicate at this point that Amarillo de Ocho as typified by Brieger *et al* (1958) in their Fig. 41, should, according to our view, be considered as an intermediate segregating phenotype between Uchuquilla and Cuzco

TABLE 13. Comparison of Cuzco Cristalino Amarillo with its Postulated Parental Races Huancavelicano and Uchuquilla.

	Huancavelicano	*Cuzco C. Amarillo*	*Uchuquilla*
Plant Characters.			
Height of Plant (cm)	132	157	133
Ear Height (cm)	48	73	55
Number of Leaves	10.9	11.3	7.0
Leaves above the Ear	5.1	5.9	4.0
Length of Leaves (cm)	55.1	73.8	58.7
Width of Leaves (cm)	8.3	9.4	7.7
Venation Index	3.04	2.8	3.98
Stalk Diameter (mm)	22.3	23.0	14.0
Days to Midsilk	140	133	129
Tassel Characters.			
Tassel Length (cm)	28.7	30.8	40.5
Length of Branching Sp. (cm)	9.2	13.9	16.5
Percent of Branching Sp.	32.0	45.1	40.7
Number of Primary Branches	11.8	12.6	17.5
Number of Secondary Branches	3.0	6.3	9.0
Number of Tertiary Branches	0	0	0.2
Condensation Index	1.02	1.00	1.00
Length of Peduncle (cm)	14.0	22.5	19.5
Ear External Characters.			
Length of Ear (cm)	11.45	13.20	16.72
Diameter of Ear	4.50	4.88	4.53
Row Number	8.75	8.42	9.46
Shank Length (cm)	6.65	8.24	13.1
Shank Diameter (cm)	1.01	1.14	1.04
Kernel Length (mm)	15.0	15.02	13.71
Kernel Width (mm)	11.6	12.69	11.30
Kernel Thickness (mm)	6.2	5.16	4.42
Ear Internal Characters.			
Cob Diameter (mm)	20.5	18.8	18.6
Rachis Diameter (mm)	13.0	12.8	11.3
Rachilla Length (mm)	1.7	2.2	0.3
Cob/rachis Index	1.58	1.52	1.64
Glume/kernel Index	0.25	0.29	0.33
Rachilla/kernel Index	0.11	0.19	0.03
Cupule Length (mm)	1.7	2.0	1.5
Cupule Width (mm)	10.8	8.4	8.6
Cupule Depth (mm)	1.5	1.2	1.2
Cupule Pubescence	1.5	2.03	2.15
Upper Glume Length (mm)	3.0	3.5	3.9
Lower Glume Length (mm)	4.2	5.9	3.5
Height Rachis Flaps	1.00	0.85	0.40
Rachis Induration	3.50	3.20	3.30

Cristalino Amarillo. Their own description of Uchuquilla does not correspond to the type of the race as defined from all available Bolivian corn collections at the Andean Corn Germplasm Bank center at Medellin, Colombia by Dr. Edgar Anderson and the present author, and as described by Ramirez *et al*, (1960).

Cuzco Cristalino Amarillo probably evolved as a distinct high-yielding standard type during early Inca times, and together with white Cuzco, laid the basis for the highly skilled and efficient agricultural organization of the Incas in the south central Andean valleys of Peru and northwestern Bolivia.

Cuzco Cristalino Amarillo has been the source of Cuzco and its extreme form Cuzco Gigante.

Derivation of Name. From the Department of Cuzco, center of distribution of this race, with the additional designation of the characters of flintiness and the yellow color of the endosperm, to distinguish this race from large, starchy kernelled Cuzco Gigante. Local names given to Cuzco Cristalino Amarillo are Uhina, Ubina, and Ckello-Sara (Herrera, 1941).

CUZCO

Plant (Fig. 152). Medium-tall, late, averaging 148 days to mid-silk at 3,200 meters and 129 days at 2,800 meters; medium number of leaves, intermediate leaf area, 4,969 sq. cm. as an average; venation index medium, 2.7; stalk wide, with no tillers, sun red in color; pubescence absent; intermediate resistance to rust and Helminthosporium leaf blight.

Cytological Characteristics. One small knob internal on chromosome 7L with a frequency of 43%, one large knob internal on 4L, 28.5%, and one medium knob internal on 3S, 28.5%. The most frequent chromosomal phenotype is only one knob and that on 7L. B-chromosomes were found in 43% of the plants with a maximum number of one per nucleus.

Tassels (Fig. 151). Peduncle medium-long, tassel length medium-short; small branching space; medium percentage branching space; branches of intermediate length and relatively small in number.

Ears, External Characters (Fig. 150). Cylindric-ovoid tapering to base and tips, intermediate in length, and relatively wide in diameter as compared to length; usually eight and sometimes ten rows of kernels distinctly outlined by the inter-row spaces, some-

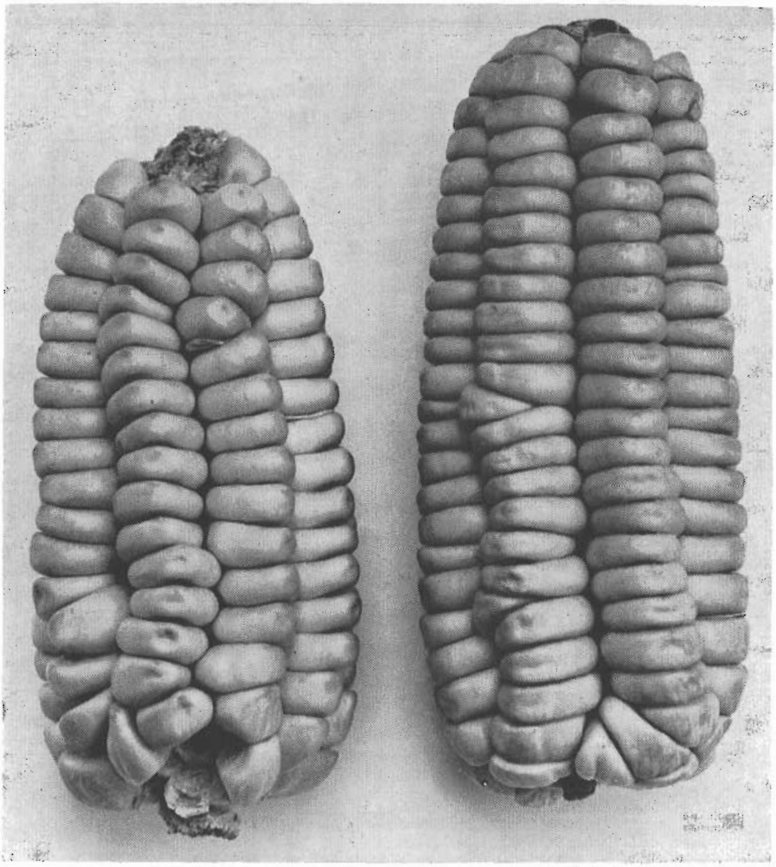


FIG. 150. Cuzco (Cuz. 61); typical ears.

time second ears, or ears of inbred plants are 4-rowed with marked bilateral symmetry; shank relatively long and wide, with low number of nodes; intermediate number of husks; kernels very long, wide, and thick, non-imbricated, slightly striated; endosperm floury, soft, white, usually lacking aleurone color; midcob color brownish in 63% of ears examined; color of glumes and lemmas red in half of the ears; pericarp and cob color frequencies: colorless-white 84.6%, red white cap-red (AP^{cr}) 9.2%, and four other combinations (Table 6A) each with 1.5%.

Ears, Internal Characters (Fig. 153). Average ear diameter 46.5 mm.; cob diameter 20.5 mm.; rachis diameter 9.3 mm.; pith diameter 5.4 mm.; estimated rachilla length medium, 1.7 mm.; cob/

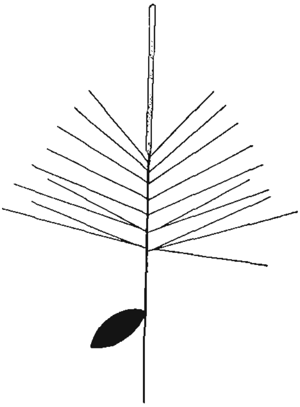


FIG. 151. Tassel diagram of Cuzco.

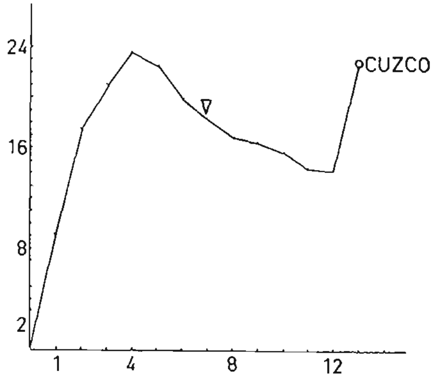


FIG. 152. Internode pattern of Cuzco.

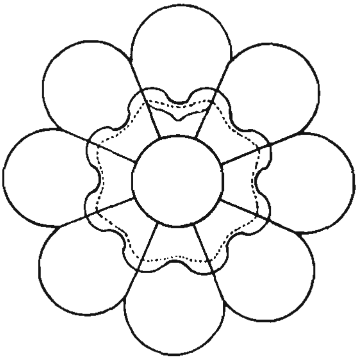


FIG. 153. Ear-cross-section diagram of Cuzco.

rachis index medium, 1.66; glume/kernel index low, 0.25; rachilla/kernel index low, 0.11; both of the last two indices having low values on account of the very large length of kernel; lower glume long with intermediate hairiness, and intermediate texture; upper glume short, slightly hairy, with medium texture and relatively strong venation; cupules medium in length, wide and intermediate in depth, very sparsely pubescent; rachis flaps very low in height, a characteristic shared with related races; rachis induration medium; tunicate allele *tu*, tripsacoid characters expressed to a low degree.

Distribution (Fig. 99). Cuzco is grown at altitudes from 2,400 to 3,300 meters above sea level on irrigated soils which are above the average in fertility, along all the central Andes from Ecuador to Bolivia and northern Argentina. The most important areas for this race in Peru are Cuzco, Cajamarca and the lower parts of Junin, Huancavelica, and Ancash. Its wide dispersal very likely was brought about by the expansion of the Inca Empire in the middle of the 15th Century A.D., either as a result of an organized agricultural policy aiming at replacing lower yielding races with Cuzco corn as a consequence of the *mitimaccunas* or *mitimaes* (resettlement of large Indian populations). Such resettlements involved transferals of populations to new environments chosen in relation to their original ones (Means, 1931), so that the domesticated plants accompanying the relocated colonists would very likely have found similar conditions to those of their original habitat. Cuzco corn was also forced into lower altitudes on the Peruvian coast and into the extremely high altitudes of the Mantaro valley, in which areas new derived races have been formed from it.

Origin and Relationships. We can recognize as Cuzco the many distinct populations of a large kernelled, floury counterpart of Cuzco Cristalino Amarillo, scattered throughout the Andes, which approach Cuzco Gigante, but have not attained the extreme dimensions and uniformity of the latter. Modern Cuzco populations have been locally isolated from Cuzco Gigante, and have experienced with it parallel evolution from their common ancester, which was presumably very much like modern Cuzco Cristalino Amarillo.

Cuzco Gigante has evolved to its extreme dimensions of ear and kernel, while Cuzco populations have maintained the usual large-kernel characteristics of the race, although hybridized with other races at various geographical locations.

The race Chancayano and Arequipeño on the Peruvian coast, San Geronimo in the Mantaro valley, and Sabanero in Cajamarca, northern Peru, have had varying degrees of Cuzco influence.

Derivation of Name. From the central area of dispersion of this race, the Department of Cuzco.

PISCCORUNTO

Plants (Fig. 155). Short, from 1 to 1.5 meters in their original habitat; early, averaging 128 days to mid-silk date at high altitudes, above 3,000 meters; number of leaves intermediate, 11.9;

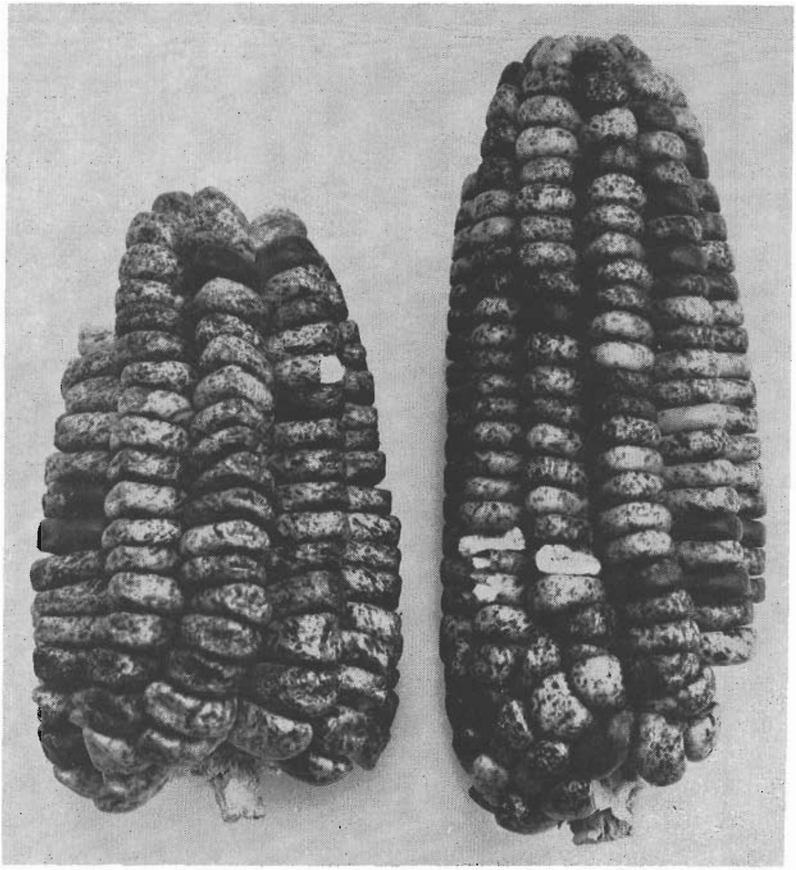


FIG. 154. Pisccorunto (Cuz. 85); typical ears, exhibiting the stippled aleurone character, always present in this race.

leaves of medium width and length with low venation index; medium leaf area 5,800 sq. cm.; few tillers; plant color ranges from purple to dilute sun red; slight sheath hairiness; ear position low; rust and Helminthosporium resistance intermediate.

Tassel. Short, short branching space; low number of primary and secondary branches, no tertiary branches.

Ears, External Characters (Fig. 154). Small, cylindro-conical to globular; average ear length 11.8 cm.; row number 12; often irregularly arranged kernels; long, slender shank, with intermediate number of nodes; low number of husks, 7.0; kernel long, wide, and of medium thickness with low depression and striation; endosperm floury, white, and soft; aleurone in a large majority of ears splashed with purple spots (this is an outstanding character of the race, highly selected for); midcob color absent in all ears examined; brownish glume color in 50% of ears; lemma color present in about one out of every six ears; all ears examined had colorless pericarp and white cob.

Ears, Internal Characters (Fig. 156). Average ear diameter 51.5 mm.; cob diameter 22.3 mm.; rachis diameter 14.7 mm.; pith diameter 7.2 mm.; estimated rachilla length short, 1.6 mm.; cob/rachis index low, 1.52; glume/kernel index low, 0.22; rachilla/kernel index very low, 0.08; lower glume short, weakly pubescent, soft, papery; upper glume of medium length, glabrous, of soft texture, and medium to strong venation; cupule length intermediate, rather wide and deep, weak hairiness; rachis induration medium; tripsacoid characteristics not present.

Distribution (Fig. 114). Pisccorunto is most frequent in the southern Sierra region in the Departments of Apurimac and Cuzco at an altitude of 3,000 meters above sea level. It is grown in small plots or less often is selected from segregating mixtures, being the ear type prized second only to Chullpi as roasting (parching) corn; Indian farmers consider that the aleurone blotching phenotype is associated with tenderness of texture of endosperm, a desirable trait for parching corn.

Origin and Relationships. The origin of this race is very likely to be found in the ancestral Confite Chavinense complex in southern Peru. Pisccorunto resembles other races derived from

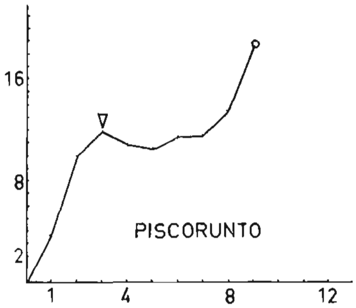


Fig. 155. Internode pattern of Pisccorunto.

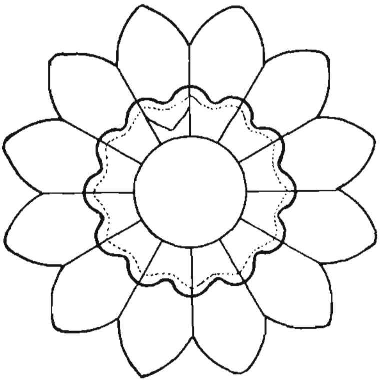


Fig. 156. Ear-cross-section diagram of Pisccorunto.

Confite Chavinense, such as Confite Puneño and Huayleño in ear characters (ear size, arrangement of kernels, kernel type and form) and plant characters (internode pattern) (Figs. 67, 73, 155). It has undoubtedly experienced hybridization with Cuzco in recent times.

Pisccorunto has been strongly selected for marbled or for stippled phenotypes.

Derivation of Name. From the Quechua word *Pisccorunto* or *Pesccoc-runtum* (Herrera, 1941), meaning birds eggs. This designation is generally used by Indian farmers to emphasize the outstanding characteristics of purple aleurone spotting in the kernels of this race. Other designations are Occe, particularly in the northern and central Sierra, Chchuspi and Checchi in southern Peru (Puno). In Bolivia it has been described under the denomination of Checchi (Ramirez *et al,* 1960).

LATELY DERIVED RACES

AREQUIPENO

Plants (Fig. 159). Medium height, average 1.97 m.; early, of same maturity range as its related race Huachano; medium number of leaves 11.2, an average of 5.6 above the ear node, medium-long, and rather wide, with low venation index, 2.20; medium-small leaf area; ear position on sixth node at height of 0.98 m. from the ground; stalk of medium thickness, with dilute sun red color, slightly pubescent and without tillers; intermediate susceptibility to Helminthosporium, fairly resistant to rust; seedling color index very high.

Cytological Characteristics. Small knob subterminal on chromosome 7L, with a frequency of 25%, and medium-small knob subterminal on chromosome 9L, with a frequency of 25%. Completely knobless plants appeared with a frequency of 25%. B-chromosomes present in one out of four collections studied.

Tassels (Fig. 158). Peduncle short; medium tassel; large branching space; length of branches medium; medium number of primary branches, large number of secondary branches, and medium number of tertiary branches; condensation index low, 1.0.

Ears, External Characters (Fig. 157). Medium length; slightly conical, thick, with 10.7 rows on the average; shank intermediate in length and width; kernels intermediate in length and thickness, fairly wide, strongly depressed at their apex (denting), strongly

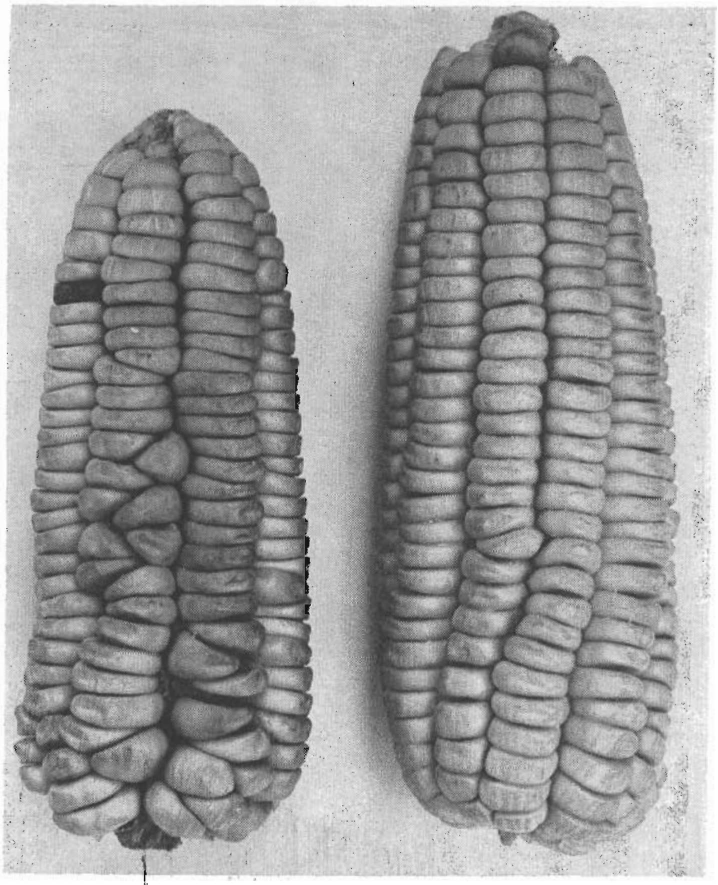


FIG. 157. Arequipeño (Areq. 16); typical ears.

striated; endosperm soft, floury, white; aleurone mostly colorless, occasionally purple; midcob color absent; glume and lemma colors red or colorless.

Ears, Internal Characters (Fig. 160). Average ear diameter 51.7 mm.; cob diameter 28.0 mm.; rachis diameter 19.0 mm.; pith diameter 9.7 mm.; estimated rachilla length medium, 2.5 mm.; cob/rachis index small, 1.47; glume/kernel index low, 0.32; rachilla/kernel index medium, 0.18; lower glume length medium-short, with intermediate hairiness, very horny; upper glume medium length; weakly pubescent, with medium hardness, weak venation; cupules very short, wide, and shallow; height of rachis flaps short, rachis very hard; tripsacoid characters present.

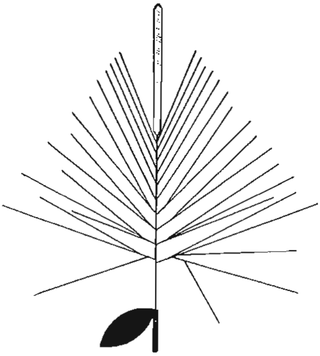


FIG. 158. Tassel diagram of Arequipeño.

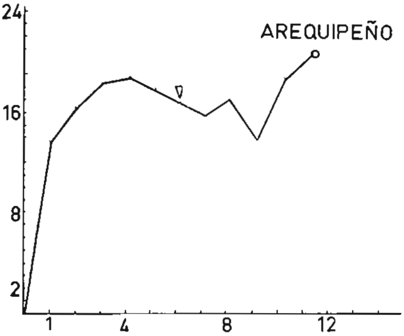


FIG. 159. Internode pattern of Arequipeño.

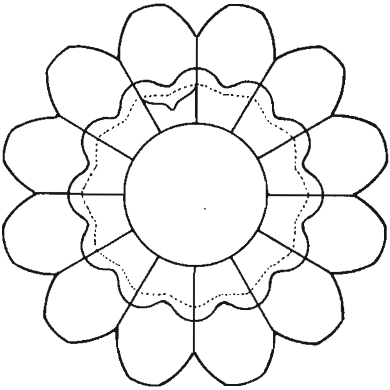


FIG. 160. Ear-cross-section diagram of Arequipeño.

Distribution (Fig. 104). Arequipeño is confined to the central and southern valleys of the Department of Arequipa, including the following: Ocoña, Sihuas, Victor, and Tambo, at medium-low altitudes, from 1,000 to 2,000 meters. A sub-race of Arequipeño, called Pachia, is grown in Tacna in the same range of altitudes.

Origin and Relationships. By reference to Tables 2A to 9A it may be observed that Arequipeño resembles other coastal floury races. It is as early as Huachano, and has a low chromosome knob number, with a knob distribution on chromosomes 7 and 9 similar to its related races Huachano, and Mochero.

The venation index of Arequipeño is among the lowest of all races, being very close to the low values of Iqueño, a sub-race of

Chaparreño, and of Coruca. In height of ear, ear length and width, Arequipeño approaches the extremely large dimensions of Chaparreño and Coruca. The internode length diagrams of Arequipeño and Chaparreño with which it is sympatrically distributed (Figs. 112, 159) show considerable similarity, as do several ear characters such as shank diameter and internal ear dimensions, midcob color, and glume and lemma color frequencies.

Although the data we have do not show a very close similarity between Arequipeño and typical Chaparreño in regard to tassel characters, since only one collection of typical Chaparreño is available, from the Department of Arequipa, they agree much better with the data for Iqueño, which is a sub-race of the Chaparreño complex. Particularly interesting in this relationship is the great length of branching space common to all races of the Blancos Criollos group, the large number of tassel branches, and especially the high number of secondary branches originating from the lower or largest primary branches.

In spite of the similarities, there are, nevertheless, significant character differences between these races. The kernels, for example, are much larger in Arequipeño, while its cupules are shorter and wider. Such differentiation in characters between Arequipeño and Chaparreño is quite well evidenced in the ear appearance of the former, which approaches more that of a Cuzcoid type (Fig. 150). The number of rows and several other ear and kernel characters of Arequipeño are intermediate between those of Chaparreño and Cuzco Gigante. The rather strong kernel depression of Arequipeño is typical of hybrids involving parents with different kernel sizes, as exemplified also by the race Chancayano.

That Arequipeño is a hybrid race between Chaparreño and Cuzco Gigante is a very plausible hypothesis for the following reasons: (a) there is geographic proximity between the original habitats of the races Chaparreño and Cuzco; (b) an intermediate altitude region approximately 2,000 meters above sea level in the valleys (Chili, upper Vitor, and Yura) surrounding the city of Arequipa where Arequipeño is grown could have provided the right habitat for hybridization between the low altitude race Chaparreño and the high altitude Cuzco; (c) there has been continuous importation of Cuzco corn into the middle altitude Arequipa area mostly for human consumption. Part of it is planted every year, so it still has an opportunity to hybridize with lower altitude races; (d) Arequipeño possesses characters intermediate between both putative parents, having kept most of the vegetative characters of its early parent Chaparreño, except for added plant vigor and having been selected for more Cuzco-like ears and kernels.

Derivation of Name. From the name of the Department of Arequipa, where this race has its center of distribution.

HUACHANO

Plants (Fig. 163). Medium-tall, average 1.96 meters; early, about 84 days to mid-silking; intermediate number of leaves, 12.6, of which 5.6 are above the ear node; leaves rather long and wide, with low venation index, 2.58; low leaf area, 4,400 sq. cm.; ears on the seventh node above ground at an average height of 1.08 m.; stalk usually green with very few small hairs; tillers very infrequent; resistant to both leaf rust and Helminthosporium leaf blight.

Cytological Characteristics. Medium sized subterminal knob on chromosome 7L present with a frequency of 33%, small terminal knob on chromosome 9S with a frequency of 50%, totally knobless plants appeared with a frequency of 50%. One plant out of six had two B-chromosomes.

Tassel (Fig. 162). Short peduncle, long tassel, 40.2 cm., with large branching space, 17.4 cm., and 43.3% of total tassel length; long branches; large number of primary and secondary branches, medium-large number of tertiaries; low condensation index, 1.03.

Ears, External Characters (Fig. 161). Medium to small, cylindrical, average length 14.7 cm. with slight taper at the tip; average number of rows 11; shank intermediate in length and width, with intermediate number of nodes, large number of husk leaves, average 10; kernels medium-long, medium-wide, and intermediate to low in thickness, non-imbricated; intermediately depressed or dented, with strong surface striations; endosperm floury and white, midcob color and lemma color absent, glumes colorless with a frequency of 90%; rachis texture very soft, pericarp and cob color colorations: colorless-white 73%, colorless-red (AP^{wr}) 27%.

Ears, Internal Characters (Fig. 164). Average ear diameter 50.11 mm.; cob diameter 29.1 mm.; estimated rachilla length large,

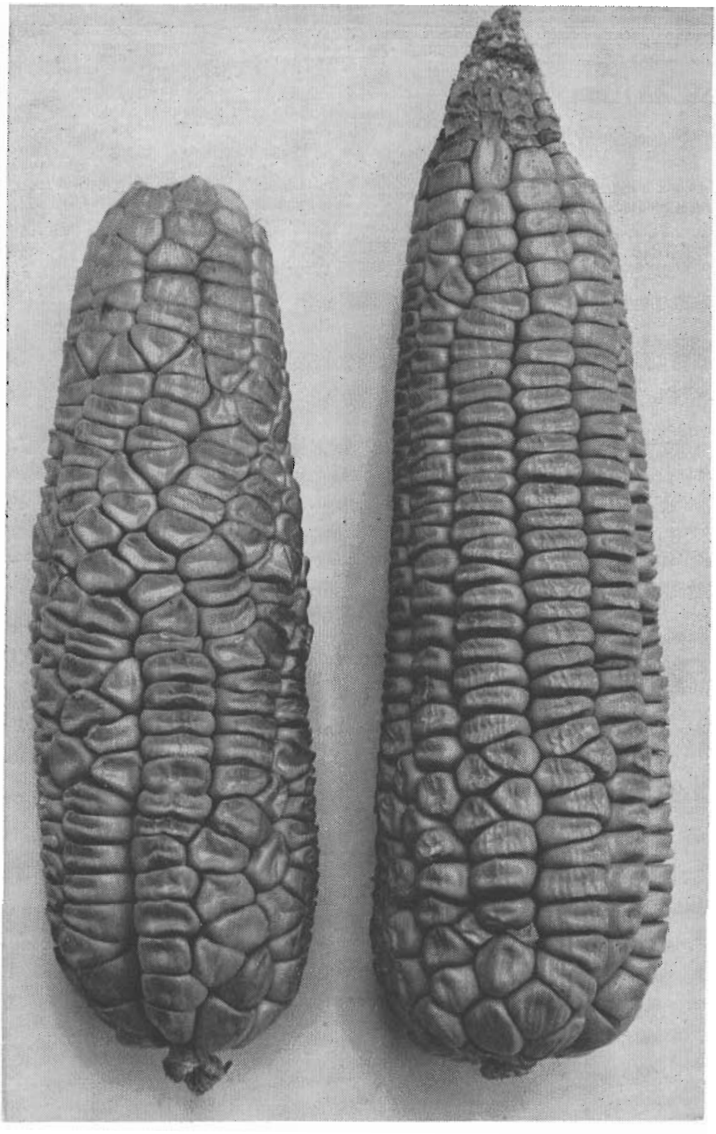


FIG. 161. Huachano (Lim. 14); typical ears. These are floury and are borne on early plants.

3.5 mm.; cob/rachis index intermediate, 1.61; glume/kernel index intermediate, 0.45; rachilla/kernel index large, 0.28; lower glume intermediate in length, with medium degree of pubescence, hard horny texture; upper glume long, with low number of hairs, very

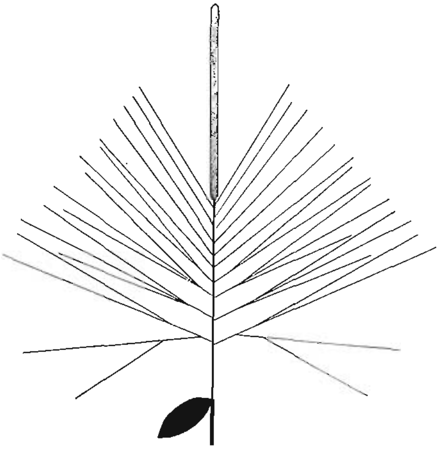


FIG. 162. Tassel diagram of Huachano.

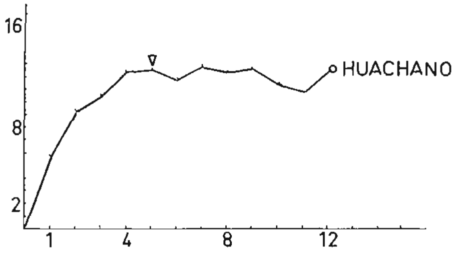


FIG. 163. Internode pattern of Huachano.

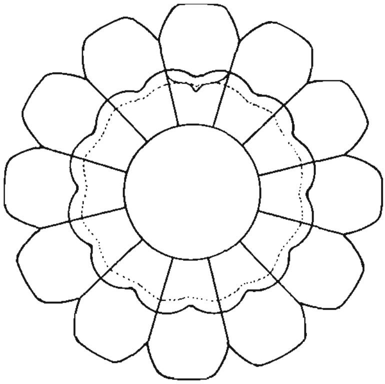


FIG. 164. Ear-cross-section diagram of Huachano.

hard texture and medium venation; cupule short, very wide and shallow and very strongly pubescent; height of rachis flaps medium; rachis very hard; tripsacoid characters present.

Distribution (Fig. 104). Huachano is limited in its distribution to the lower alluvial fans of a few Central Coast valleys. Its major concentration is around the town of Huacho in the Huaura valley, but it is also grown in the Chancay, Pativilca, Lima-Chillon, and Huarmey valleys. Huachano is found at a mean altitude of 45 meters above sea level.

This race was grown to a greater extent a few decades ago than it is today, as a source of summer green corn.

Origin and Relationships. A detailed comparison of morphological, physiological and cytological characters between Huachano and Mochero discloses an extraordinary degree of similarity between these two races. Huachano has been modified, however, by the genetic contribution to Mochero from the race Pardo, acquiring certain major characters of the latter, such as induration of rachis and glumes, pubescence of the cupule, increased plant height, increased number of leaves and larger leaf dimensions, and thicker stalk. In many other characters it remains intermediate between Pardo and Mochero, and in still others, such as internode length pattern (see Figs. 102, 163 and 202) and several tassel and ear characters, Huachano is much like Mochero (Table 14).

Huachano was selected as a *choclo* (green) corn for summer production because of its comparative earliness, intermediate between that of its putative parents, and a rather small ear, slightly larger than Mochero. The ear type of Huachano can very easily be recognized as partaking of the general appearance of both putative parents.

It is interesting to note that even though Huachano exhibits strong induration and pubescence in the ear structures, its chromosome knob pattern conforms closely to the Andean low-knob type. Besides the standard chromosome 7 long arm knob, typical of most Peruvian highland corn races, it carries knobs in the same chromosome 9 short arm position as its putative parent Mochero. This is an interesting case of induration of the cob structures, unaccompanied by increase in chromosome knob numbers, which does not conform to the general pattern found in tripsacoid maize races of the Middle American region of influence.

The retention of low number of knobs and presence of B-chromosomes in both Mochero and Huachano, growing in geographical areas where these races are sympatric with high knob-number races with no B-chromosomes, may be explained by the presence of physiological and selective barriers. The extreme earliness of Mochero under the arid growing conditions of the North Coast effectively prevents this race from being contaminated by Alazan or Arizona which are more mesophytic, at least 20 days later than Mochero, and all grown in proximity to Mochero in areas where

TABLE 14. Comparison of Huachano with its Postulated Parental Races Mochero and Pardo.

	Mochero	*Huachano*	*Pardo*
Plant Characters.			
Height of Plant (cm)	153	196	204
Ear Height (cm)	93	108	115
Number of Leaves	10.4	12.6	11.9
Leaves above the Ear	3.8	5.6	4.5
Length of Leaves (cm)	75.8	81.9	81.3
Width of Leaves (cm)	8.8	9.5	8.9
Venation Index	2.74	2.58	2.30
Stalk Diameter (mm)	18.3	19.5	19.7
Days to Midsilk	69	84	99
Tassel Characters.			
Tassel Length (cm)	37.9	40.2	46.2
Length of Branching Sp. (cm)	16.8	17.4	17.7
Percent of Branching Sp.	44.3	43.3	38.3
Number of Primary Branches	23.6	19.2	12.9
Number of Secondary Branches	15.2	11.6	8.1
Number of Tertiary Branches	2.7	1.1	1.0
Condensation Index	1.09	1.03	1.00
Length of Peduncle (cm)	11.4	12.0	11.4
Ear External Characters.			
Length of Ear (cm)	7.63	14.70	19.66
Diameter of Ear (cm)	4.13	4.61	4.20
Row Number	Irreg.	10.96	7.80
Shank Length (cm)	6.50	6.18	9.62
Shank Diameter (cm)	—	0.94	0.90
Kernel Length (mm)	9.90	11.47	12.10
Kernel Width (mm)	7.60	10.78	12.30
Kernel Thickness (mm)	4.50	4.46	4.50
Ear Internal Characters.			
Cob Diameter (mm)	24.8	29.1	20.6
Rachis Diameter (mm)	16.1	18.1	12.0
Rachilla Length (mm)	2.7	3.5	1.2
Cob/rachis Index	1.54	1.61	1.71
Glume/kernel Index	0.44	0.45	0.35
Rachilla/kernel Index	0.27	0.28	0.10
Cupule Length (mm)	1.4	1.7	1.9
Cupule Width (mm)	7.9	9.6	7.9
Cupule Depth (mm)	1.1	1.3	1.4
Cupule Pubescence	1.50	2.25	2.30
Upper Glume Length (mm)	4.7	4.8	4.4
Lower Glume Length (mm)	6.1	5.5	5.7
Height Rachis Flaps	1.90	1.50	1.40
Rachis Induration	2.80	3.75	3.90

somewhat more irrigation water is available. On the Central Coast Huachano is effectively kept free from high-knob number race contamination because the outcrossed kernels may be easily spotted and selected out, since they exhibit the yellow endosperm characteristic of these races.

Derivation of Name. Huachano is named after the town of Huacho, Department of Lima, in the vicinity of which are found the most extensive plantings of this race. Another name with which this race is known is Cuatromesino or four-monther, which refers to its earliness as compared to all other races of the same area.

CHANCAYANO

Plants (Fig. 167). Very tall, late maturing plant; averaging 96 days to mid-silk when grown at La Molina; large number of leaves, 13.1, very long and wide, with large leaf area, 7,200 sq. cm.; leaf pattern index high on Quadrant II, 89%; venation index low; ear position medium-high; leaves above upper ear 5.4; prop roots usually well developed; stalk very thick, having the largest diameter of all coastal races; tillers few and sporadic, but having the largest frequency of occurrence of any Peruvian race; plant pubescence slight with small soft hairs; plant color green; highly resistant to rust and Helminthosporium.

Cytological Characteristics. Large to medium knob subterminal on 7L, frequency 75%; large knob subterminal on 4L 25%; medium knob subterminal on 6L 25%; small knob terminal on 8S 25%; large knob subterminal on 9L, 25%; most frequent class one knob per nucleus; one of four plants examined had four B-chromosomes and knobs on 6L, 7L, and 8S, while the other three plants had no B-chromosomes.

Tassel (Fig. 166). Peduncle medium in length, total tassel length large, 42.4 cm.; branching space intermediate; branches very long; intermediate number of primary branches, medium-large number of secondaries, and intermediate number of tertiary branches; condensation index low, 1.06.

Ears, External Characters (Fig. 165). Medium-long, broad, cylindrical to cylindro-conical with a slight taper toward the tip; an average of 11.7 rows of kernels; shank medium long, wide, with a large number of nodes; large number of husks, 9.2; kernels of medium length, wide, and of medium thickness with a rather

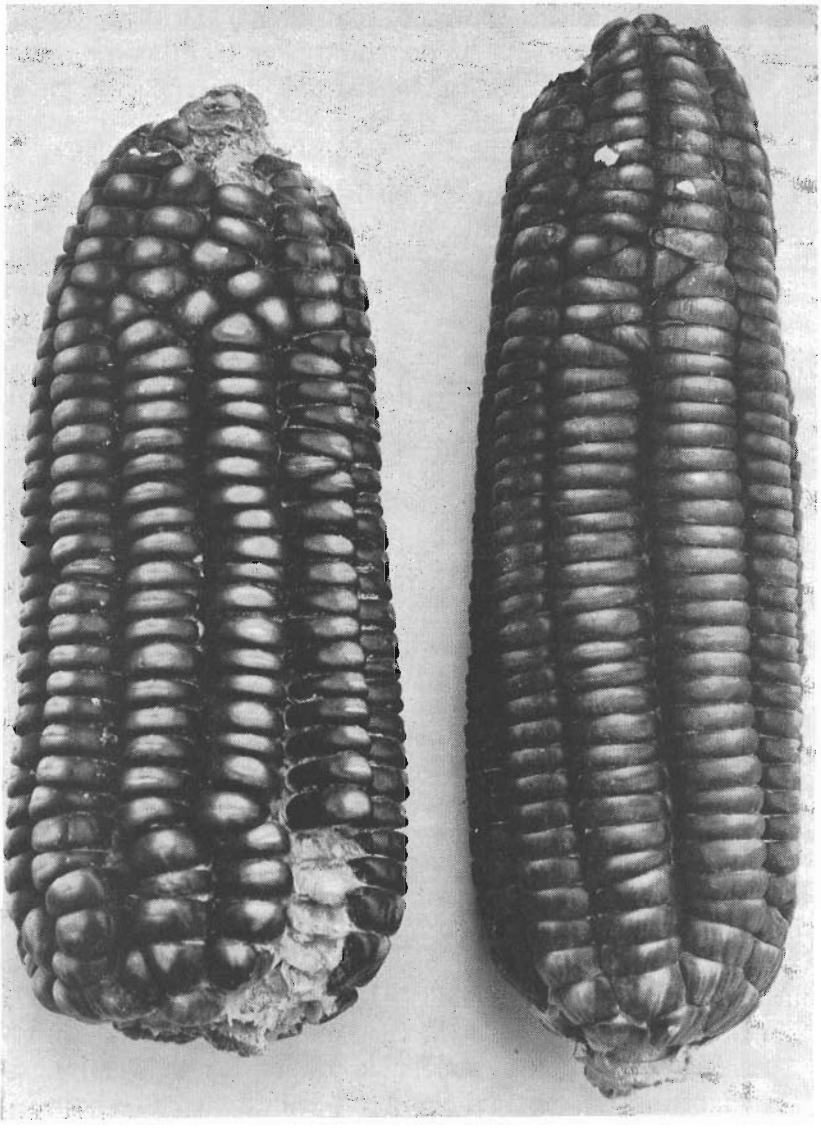


FIG. 165. Chancayano (Lim. 46); typical ears. This race, grown in the Central Coast valleys shows a definite Cuzcoid influence.

deep depression at their crown and fairly well striated on their surface; endosperm white, floury, and soft; aleurone usually colorless; midcob color absent; glumes colorless; lemmas colorless in ⅔ of ears examined. Pericarp and cob color combinations follow two definite patterns. In the sub-race Chancayano Blanco all

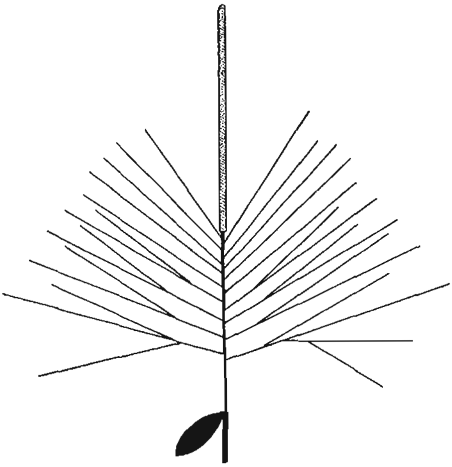


FIG. 166. Tassel diagram of Chancayano.

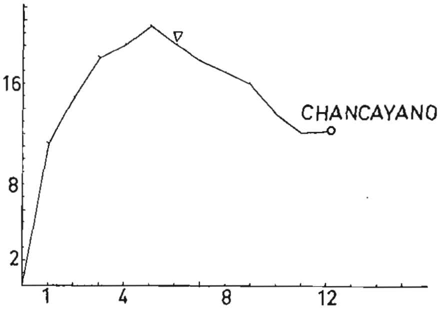


FIG. 167. Internode pattern of Chancayano.

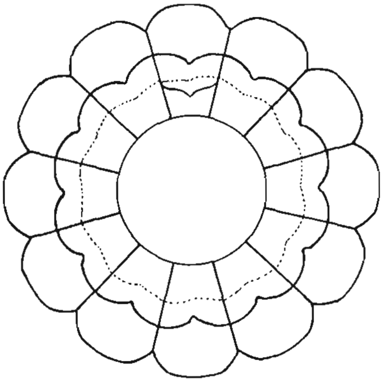


FIG. 168. Ear-cross-section diagram of Chancayano.

ears are colorless pericarp, white cob, while in the sub-race Chancayano Printado 80% are red white cap-white *(AP^{cw})*, and 20% are red white cap-red *(AP^{cr})*.

Ears, Internal Characters (Fig. 168). Average ear diameter 49.4 mm.; cob diameter 30.9 mm.; rachis diameter 19.8 mm.; pith diameter 11.1 mm.; estimated rachilla length long, 3.0 mm.; cob/rachis index low, 1.56; glume/kernel index high for Peruvian races, 0.48; rachilla/kernel index intermediate, 0.25; lower glume very long, 6.9 mm.; sparsely pubescent, texture horny, medium-

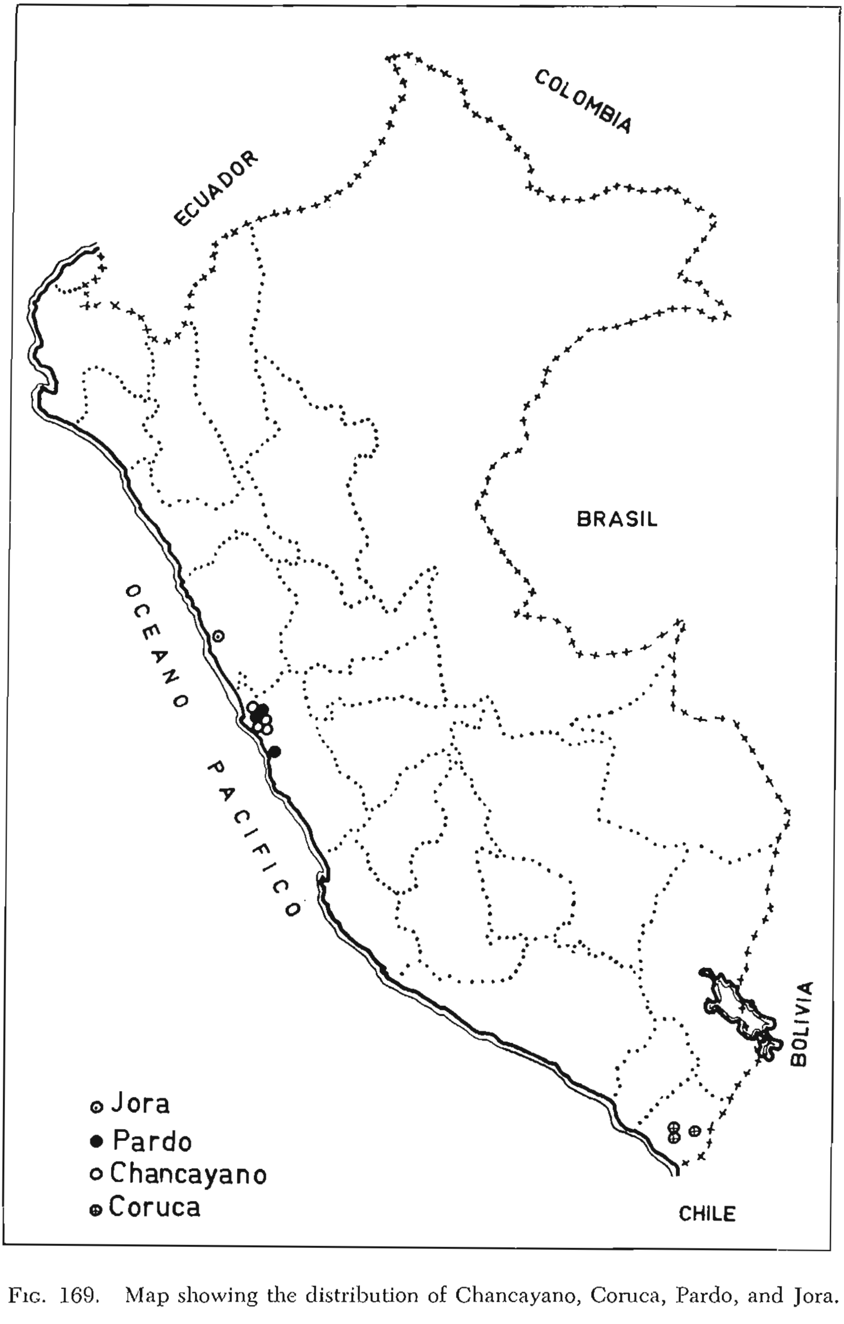


Fig. 169. Map showing the distribution of Chancayano, Coruca, Pardo, and Jora.

hard; upper glume long with slight pubescence, rather hard, scantily veined; cupules long, very wide and fairly deep, with pronounced hairiness; rachis flaps intermediate in height; rachis induration relatively high; tripsacoid characters expressed to an intermediate extent.

Distribution (Fig. 169). Chancayano has its center of distribution in the Huaura valley, a few miles from the Pacific Ocean. From here it radiates northward to the Supe-Pativilca-Fortaleza valleys, and southward to the Chancay and Lima valleys, all within the boundaries of the Department of Lima. In these areas Chancayano is grown at elevations below 200 meters above sea level.

As recently as 20 to 30 years ago, Chancayano was widely grown in the above mentioned valleys as the basic feed for hogs, particularly in the neighborhood of the city of Huacho, being preferred for that purpose on account of its large starchy, soft kernels. It has now been largely displaced by the flint race Perla.

Origin and Relationships. It appears likely that Chancayano is a hybrid race between Alazan and Pardo. Internal and external ear and kernel characters, plant internode pattern, and tassel characters are mostly intermediate in Chancayano between those of its parental races (Table 15). In 21 characters Chancayano is intermediate or not significantly different from one or the other parent; it exceeds character values for either parent in 10 cases and is lower in 5. Furthermore, Chancayano in one of its two characteristic forms, the sub-race Chancayano Pintado, exhibits a red pericarp with white-cap (Chancayano Blanco, white kernelled, is the other sub-race). Such a pericarp color is very frequent in Alazan, the only other race on the coast of Peru which has this phenotype in any large frequency.

The presence of knob positions intercalary on chromosome arms 4L, 6L and 9L, and terminal on 8S, in Chancayano coincides with the frequency of such knob positions in Alazan.

Intermediate ear forms between Huachano and Alazan, which local farmers also call Chancayano, have been found. These, however, may be easily distinguished by their shorter ear length, usually more marked kernel denting, and lack of the characteristic big cigar shape of Chancayano ears.

The time of origin of Chancayano may well have been late Chimu or Coastal Inca Periods. Ears which closely resemble

TABLE 15. Comparison of Chancayano with its Postulated Parental Races Alazan and Pardo.

	Alazan	*Chancayano*	*Pardo*
Plant Characters.			
Height of Plant (cm)	214	192	204
Ear Height (cm)	138	99	115
Number of Leaves	12.7	13.1	11.9
Leaves above the Ear	4.9	5.9	4.5
Length of Leaves (cm)	87.2	87.0	81.3
Width of Leaves (cm)	9.9	10.2	8.9
Venation Index	2.70	2.36	2.30
Stalk Diameter (mm)	21.2	26.0	19.7
Days to Midsilk	93	96	99
Tassel Characters.			
Tassel Length (cm)	36.9	42.4	46.2
Length of Branching Sp. (cm)	16.6	15.4	17.7
Percent of Branching Sp.	44.9	36.3	38.3
Number of Primary Branches	23.6	18.8	12.9
Number of Secondary Branches	12.0	9.5	8.1
Number of Tertiary Branches	1.1	0.7	1.0
Condensation Index	1.10	1.06	1.00
Length of Peduncle (cm)	12.0	14.3	11.4
Ears External Characters.			
Length of Ear (cm)	15.84	14.78	19.66
Diameter of Ear (cm)	4.90	5.27	4.20
Row Number	14.15	11.66	7.80
Shank Length (cm)	6.87	7.97	9.62
Shank Diameter (cm)	1.34	—	0.90
Length of Kernel (mm)	10.60	11.80	12.10
Width of Kernel (mm)	9.20	11.40	12.30
Thickness of Kernel (mm)	4.80	4.80	4.50
Ear Internal Characters.			
Cob Diameter (mm)	30.2	30.9	20.6
Rachis Diameter (mm)	14.5	19.8	12.0
Rachilla Length (mm)	1.0	3.0	1.2
Cob/rachis Index	1.56	1.56	1.71
Glume/kernel Index	0.50	0.48	0.35
Rachilla/kernel Index	0.09	0.25	0.10
Cupule Length (mm)	3.4	2.3	1.9
Cupule Width (mm)	10.3	11.5	7.9
Cupule Depth (mm)	2.4	2.0	1.4
Cupule Pubescence	1.74	2.11	2.30
Upper Glume Length (mm)	5.4	4.5	4.4
Lower Glume Length (mm)	6.2	6.9	5.7
Height Rachis Flaps	1.87	1.50	1.40
Rachis Induration	2.87	3.77	3.90

Chancayano appear molded on Mochica pottery (Fig. 36); their biometrical characteristics are given in Table 5A.

During the last 30 years, considerable natural hybridization has taken place between Chancayano and Perla, the two largest yielding modern races of the Central Coast. The result is the formation of an incipient new race Chancayano Amarillo, vigorous and intermediate in ear characters between both parents.

Derivation of Name. From the valley of Chancay, some 40 miles north of Lima, where this race was once widely grown. Chancayano is the designation commonly applied by farmers to this race.

SAN GERONIMO-HUANCAVELICANO

Plants (Fig. 172). Short, early, averaging 134 days to mid-silk date, when grown at 3,200 meters above sea level in Cuzco; low number of short and narrow leaves, leaf area low, 1,245 sq. cm.; leaf pattern index high, 87% on Quadrant II; venation index very high, 3.5; ear position low on fifth node at an average height of 50 cm. above ground; stalk slender, without developed prop roots or tillers; pubescence absent; plant color sun red to purple; slight resistance to rust and Helminthosporium.

Tassel (Fig. 171). Peduncle long; tassel short; branching space 50% of total tassel length; branches short; number of primary, secondary, and tertiary branches small; condensation index low.

Ears, External Characters (Fig. 170). Short, average length 8.10 cm., ovoid (hand grenade) shaped, average number of rows 11.1; shank very short, 4.7 cm., slender with small number of nodes, 4.5; small number of husk leaves, 5.4; kernels long, wide, and thick; with medium denting and slight striation, non-imbricated; endosperm white, floury, and fairly soft; aleurone often colorless; midcob color present in 50% of ears; lemmas colored in 40% of ears; pericarp and cob color combinations: colorless pericarp-white cob 61.8%, colorless-red (AP^{wr}) 16.4%, red-red (AP^{rr}) 6.3%, brown-brown ($A^{b'}P^{rr}$) 6.3%, variegated red-variegated red (AP^{vv}) 4.5%, and four other combinations with a combined frequency of 4.5% (Table 6A).

Ears, Internal Characteristics (Fig. 173). Average ear diameter 49.4 mm.; cob diameter 22.7 mm.; rachis diameter 14.5 mm.; pith diameter 6.1 mm.; estimated rachilla length short, 1.3 mm.; cob/rachis index low, 1.55; glume/kernel index low, 0.25; rachilla/

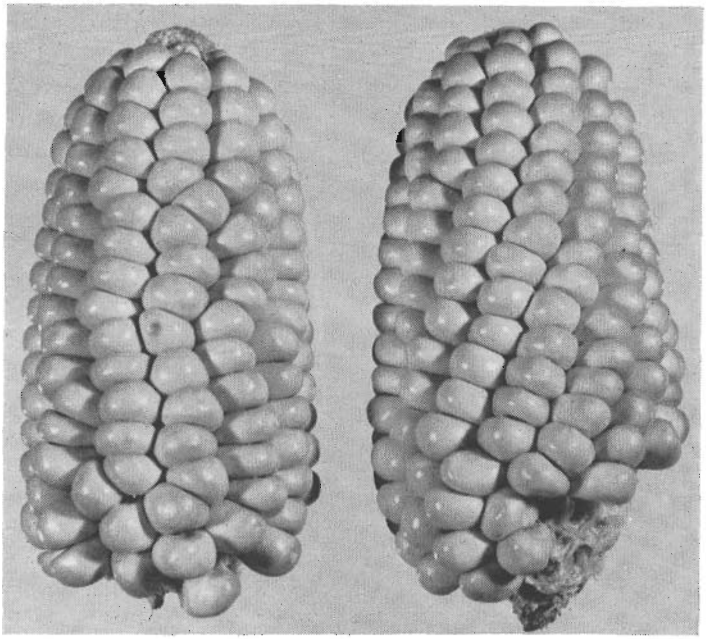


FIG. 170. Typical ears of San Geronimo-Huancavelicano.

kernel index low, 0.08; lower glume long, very sparsely haired, of intermediate texture; upper glume length intermediate, hairiness slight, texture medium-soft, venation intermediate; cupules medium in length and depth, and rather wide, weakly pubescent; rachis flaps fairly low in height; rachis induration low; tunicate allele *tu;* expression of tripsacoid characters absent.

Distribution (Fig. 89). The center of distribution of this race is the Department of Huancavelica, partly in the Mantaro valley and reaching north to Junin. Two main areas are recognized within Huancavelica: Pampas, and Lircay, where San Geronimo-Huancavelicano is grown at a mean altitude of 3,100 meters, and ranging between 2,500 to 3,500 meters above sea level.

Origin and Relationships. It is readily apparent from a comparison of this race with Huancavelicano that they are related. San Geronimo-Huancavelicano is apparently an incipient new synthetic race which arose through hybridization of Huancavelicano with other sympatrically distributed races, particularly Paro and to a lesser extent Chullpi. The resulting populations approach

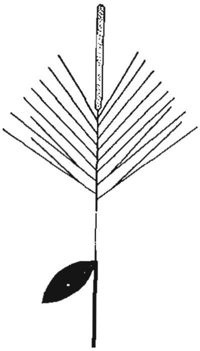


FIG. 171. Tassel diagram of San Geronimo-Huancavelicano.

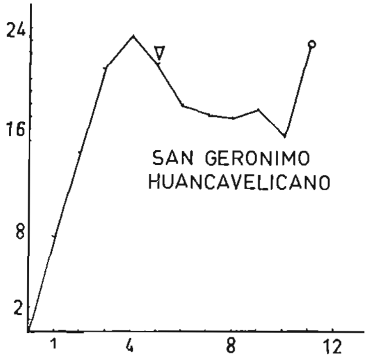


FIG. 172. Internode pattern of San Geronimo-Huancavelicano.

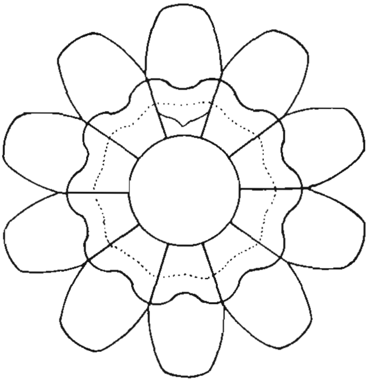


FIG. 173. Ear-cross-section of San Geronimo-Huancavelicano.

Huancavelicano very closely in plant characters, but the ears are more globose, thicker, with a larger row number, and very often tending to irregular kernel arrangement rather than to a straight rowing like the Paro or Chullpi parents.

San Geronimo-Huancavelicano is intermediate in appearance, in general plant characters and in ear shape between Paro and the race San Geronimo. Particularly, it has taller plants and ears with smaller kernels than this latter race.

Derivation of Name. No generalized name being available for this race, a compound designation was adopted indicating the two races, San Geronimo and Huancavelicano, with closest morphological affinities to it.

PERLA

Plants (Fig. 176). Very tall, late, averaging 97 days to mid-silk date when planted at La Molina; large number of leaves; leaf area large, 8,500 sq. cm.; high value of leaf pattern index for Quadrant II, 96.6%; leaf venation index low, 2.51; stalks wide, with strong prop root development, but susceptible to lodging; very few tillers; pubescence slight; plant color sun red to dilute sun red; resistant to rust and Helminthosporium.

Cytological Characteristics. Total number of chromosome knobs very high, varying from 6 to 13, with 7 to 9 being in the largest frequencies. Distribution and frequency of knob positions as follows: subterminal knobs on chromosome 1S, small, 30.7%; 1L medium, 30.7%; 2S medium 23.1%; 2L large, 33%; half of which are heterozygous; 3S medium to large, 16.7%; 3L large to small, 30.7%, one fourth of which are heterozygous; 4S large, 6%; 4L large, 73%; one additional small knob position on 4L 6%; 5S medium to small, 14.3%, half of them heterozygous; 5L large, 33%; 6L small, 93%, of which 23% are heterozygous; 6L chromosome arms with at least one additional knob position, 53%; 7L medium-large, 94%, of which one fourth are heterozygous; 7L chromosome arms with at least one additional knob 6%; 8L large to small, 73%, of which 45% are heterozygous; additional knob positions on 8L on 26.6% of plants; 9S medium, 6%; 9L large to medium, 76.5%; of which 15% are heterozygous; 10L medium, 5.9%. Terminal knobs: 2S medium to small, 30.7%; 2L medium, 8%; 3S small to large, 25% 7S medium, 37.5%, 1/6 of which are heterozygous; 8S medium, 6.7%; 9S large to medium, 82%, of which 14% are heterozygous; there are at least 25 knob positions. B-chromosomes are absent.

Tassels (Fig. 175). Peduncle short; length of tassel intermediate to long; branching space large; length of branches intermediate; number of primary branches large; number of secondary and tertiary branches intermediate; condensation index low, 1.07.

Ears, External Characters (Fig. 174). Medium-long, cylindrical to cylindro-conical; average number of rows 15.6; medium-long shank, wide, and with large number of nodes; kernels short, narrow, and of medium thickness; denting absent or slight; striations strong; endosperm yellow, flinty, and hard; midcob color absent in 35% of ears, red in 40% and brownish in the remainder;

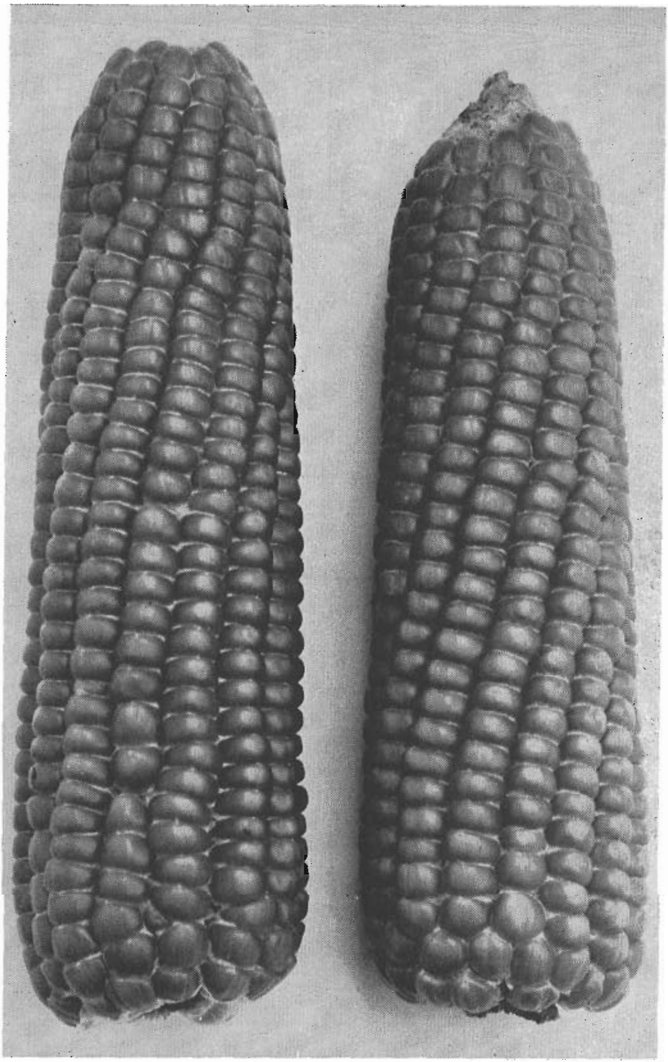


FIG. 174. Perla (Lim. 8); typical ears. This is one of the most widely grown races in the Central Coast.

glumes and lemmas not pigmented in 96% of ears examined; pericarp and cob color combinations: colorless-white 42.5%, colorless-red (AP^{wr}) 12.4%, orange white (AP^{ow}) 36.3%, brownish red-brownish red ($a^{p1}P^{rr}$) 3.1% orange-red (AP^{or}) 2.6%; four other combinations with lower frequencies. (Table 6A).

Ears, Internal Characters (Fig. 177). Average ear diameter 45.0

mm.; cob diameter 31.2 mm.; rachis diameter 19.1 mm.; pith diameter 94. mm.; estimated rachilla length long, 3.1 mm.; cob/rachis index low, 1.63; glume/kernel index very high, 0.62, highest among Peruvian corn races; rachilla/kernel index very high, 0.32; lower glume very long, 7.4 mm., longest among Peruvian races, strongly pubescent, horny, very hard; upper glume very long, 5.3 mm., hairy, very hard, venation strong; cupules intermediate in length and in depth, wide, sparsely pubescent; rachis flaps high and prominent; rachis induration very strong; tunicate allele tu^h, half tunicate; tripsacoid characters strongly expressed.

Distribution (Fig. 178). The present day distribution of Perla comprises all the valleys of the Central and North Coast regions of Peru, from Chincha in the south to Viru in the north. In recent years, improved varieties of Perla, since it is the most productive among lowland races, have found their way further north and south along the Coast, also into the eastern Andean slope farming areas, particularly in the Callejon de Huaylas, Department of Ancash, and are discontinuously distributed, as well, in other low altitude areas within the Andean mountain ranges. The largest areas where Perla varieties are grown are the valleys of Lima, Chancay, Huaura, Pativilca, and Casma.

It appears from the scattered information that we have been able to gather that the culture of Perla was more prevalent in past years in the valleys north of the cooler Central Coast cloudy climatic belt. In this latter area the floury corns prevailed at the beginning of this century, before being largely substituted by Perla.

Tschudi (1847), reporting on his travels in Peru between 1838 and 1842, describes a type of corn growing on the Coast which he calls *Maiz Amarillo de Chancay.* It had semi-transparent square-shaped grains, and an elongated ear. The race Perla fits very well his description.

Origin and Relationships. The many morphological and cytological resemblances and the overlapping distributions of Perla and Alazan suggest a direct and close relationship between these two races.

Flint and floury forms of Proto-Alazan must have coexisted since pre-hispanic times on the northern Peruvian coast. Presumably, selection for types of maize adapted to the various forms of human consumption of corn in Peru would have, undoubtedly,

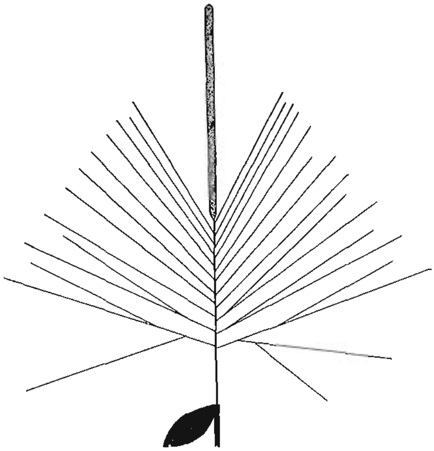


FIG. 175. Tassel diagram of Perla.

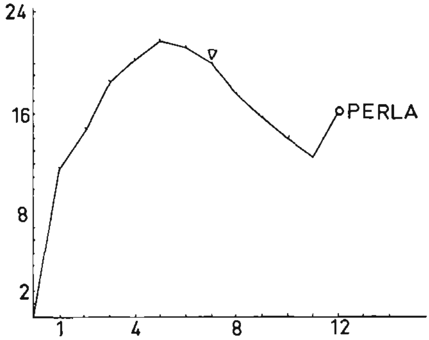


FIG. 176. Internode pattern of Perla.

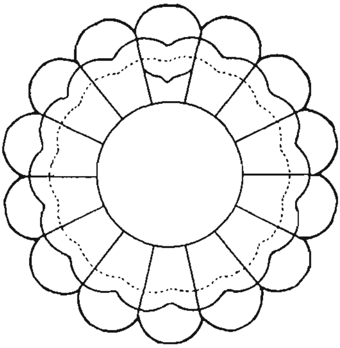


FIG. 177. Ear-cross-section diagram of Perla.

favored the floury form. Later, at the time of the Inca invasions, Uchuquilla, a highland race from southern Peru and Bolivia, could have been brought to the coast where it hybridized with Alazan to produce Perla.

In support of this hypothesis we may point out the interesting similarities between Perla and Uchuquilla: high frequencies of the orange pericarp alleles, P^{or} and P^{ow}, (Table 6A), the relatively large kernel width/length ratio of these races, the intense sun red plant coloration, extended vegetative period, and other characters (Tables 2A to 8A).

It appears that Perla has also experienced considerable intro-

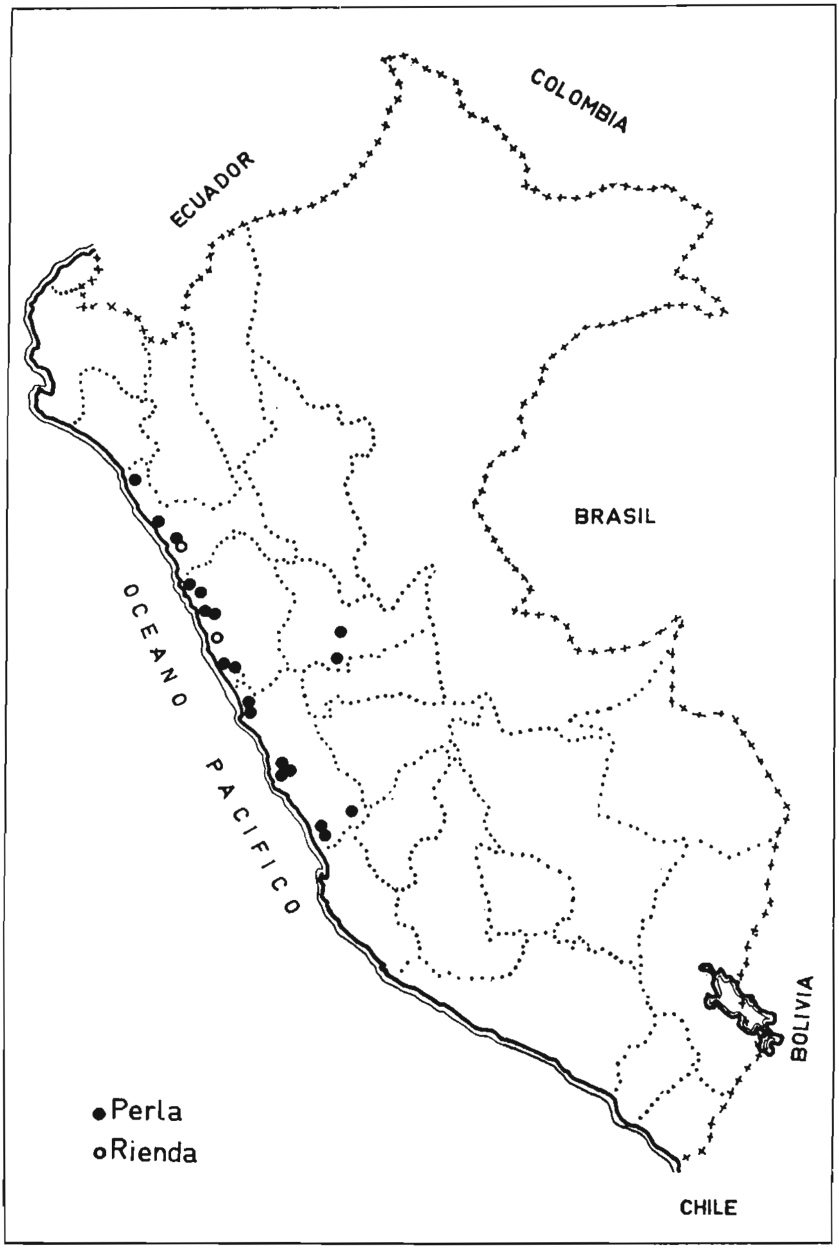


FIG. 178. Map showing the distribution of Perla and Rienda.

gression from *Tripsacum australe,* either through Piricinco or a race related to it. This is particularly evidenced by the introduction into Perla, with high frequency, of the half tunicate allele, which conditions long glumes on the ears. The long glume character appears in Peru in races which presumably have received it from *Tripsacum australe,* either directly or through Piricinco. It is plausible that Perla, in turn, may have experienced such Piricinco influence indirectly through prior hybridization of this latter race with Alazan.

To add further to the complexity of Perla, within at least the last 30-40 years some additional gene flow has taken place into Perla from introductions of a flint corn from Colombia, which resembles Amagaceño or Costeño.

The extreme vigor of Perla, and the high agronomic value of this race could likely have come about through wide-cross heterosis. We visualize the genetic interactions leading to the evolution of Perla as derived from heterotic effects between blocks of genes contributed by a Colombian Tripsacum pool (through the Colombian race Chococeño), and other South American (knobless) Tripsacums, as well as between both Tripsacum gene groups and corn (Fig. 237).

Very high mutation rates for albino seedlings (1-2%) have been observed in lines derived from Perla, strongly suggesting that mutagenic forces associated with wide crossing and Tripsacum gene block effects (Mangelsdorf, 1958a) are the result of the complex hybrid condition of that race.

Derivation of Name. From the name given to this race by local farmers.

RIENDA

Plants (Fig. 183). Tall, average height 2.74 meters; maturity medium to late; 113 days to mid-silk on the Central Peruvian Coast; large number of leaves, 14; length of leaf medium, width medium-large, venation index medium, 2.64; leaf area rather small, 5,116 sq. cm.; ear on the ninth node, at an average height of 1.84 meters from the ground; average number of leaves above the ear 6; stalk thick, without tillers; color frequently dilute sun red; strong development of prop roots; slight hairiness; moderate resistance to rust, resistant to Helminthosporium.

Cytological Characteristics. At least 13 different knob positions have been found in cytological analyses of Rienda. The presence of fused knobs has impaired the accuracy of identification of knob positions. However, the following minimum frequencies may give an idea of the relative prevalence of the several knob positions. Subterminal medium sized knobs: 1S 25%; 1L 25%; 2L 25%; 3L 25%; 4S 25%; 4L 50%; 5L 25%; 6L 50%, and an additional knob on 6L 25%; 7L 50%; 8L 50%; 9L 75%; terminal medium sized knobs: 7S 50% (large knob), 9S 75%. Total number of knobs per plant was six in the only collection completely analyzed. No B-chromosomes were found.

Tassel (Fig. 182). Peduncle long, tassel long, longest branching space of any Peruvian race, 20.8 cm., large branching space percentage, branches medium-long; large number of primary branches, 20.5 and a markedly large number of secondary branches, 19.3, with no tertiary branches; condensation index low, 1.05.

Ears, External Characters (Fig. 179, 180, 181). Long, cylindrical to slightly cylindro-conical, slender and flexible, average number of rows 14; kernels of medium length, width and thickness, nonimbricated, although occasional slightly imbricated ears may be found; crown depression strong in some collections, giving a slight denting, while it is absent in other collections; surface striations very strong; endosperm yellow, flinty or semiflinty; aleurone colorless; midcob color 70% red or reddish brown, 20 to 30% white; glumes red in 80% and lemmas red in 90% of ears examined; pericarp and cob color combinations about evenly divided between colorless pericarp-white cob (55.6%) and colorless pericarp-red cob (44.4%).

Ears, Internal Characters (Fig. 184). Average ear diameter 34.7 mm.; cob diameter 18.5 mm.; rachis diameter 8.5 mm.; pith diameter 2.7 mm.; estimated rachilla length long, 3.6 mm.; cob/rachis index very high, 2.17; glume/kernel index high for Peruvian races, 0.53; rachilla/kernel index very high (highest among Peruvian races), 0.38; lower glume length intermediate, moderately hairy, texture fairly soft; upper glume long, slight to moderately hairy, soft-textured, sparsely veined; cupules very long, very narrow, and of intermediate depth; rachis flaps of intermediate height; rachis induration very slight; tunicate allele tu^w; tripsacoid characters reduced to a minimum expression.

Distribution (Fig. 178). It appears from archaeological evidence

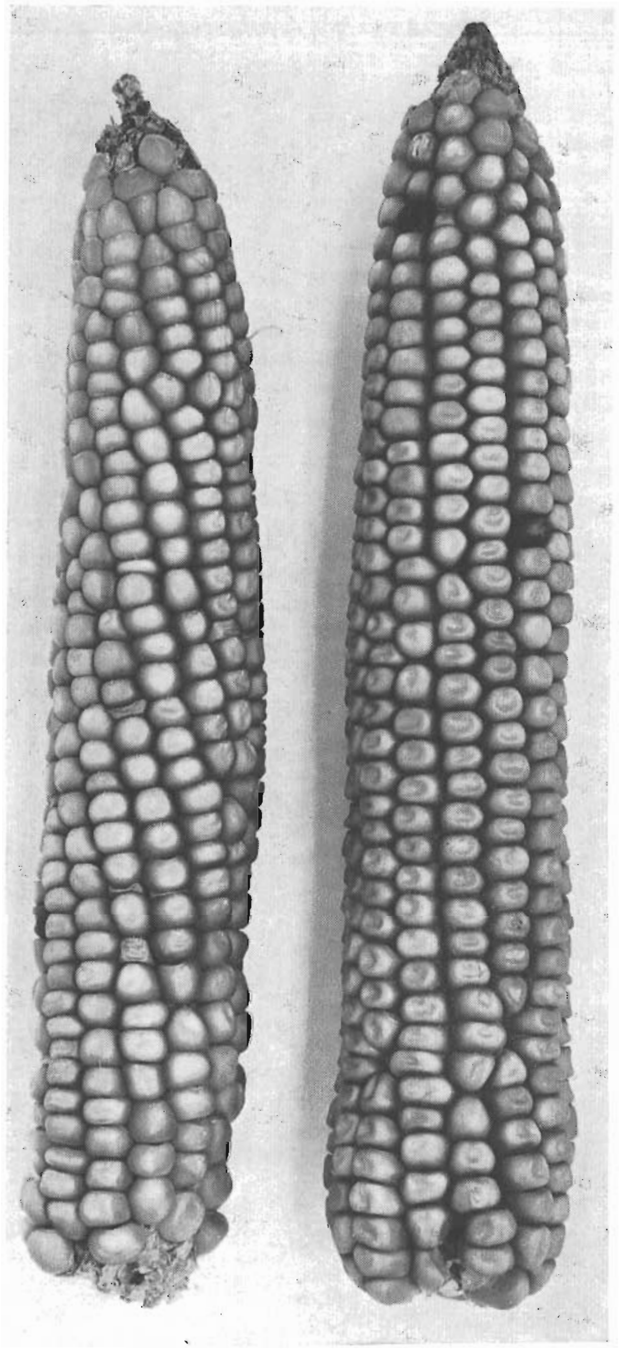


Fig. 179. Rienda; typical ears. The ear at the right exhibits partial interlocking, a character which together with a flexible cob it derived from its parental race Rabo de Zorro.

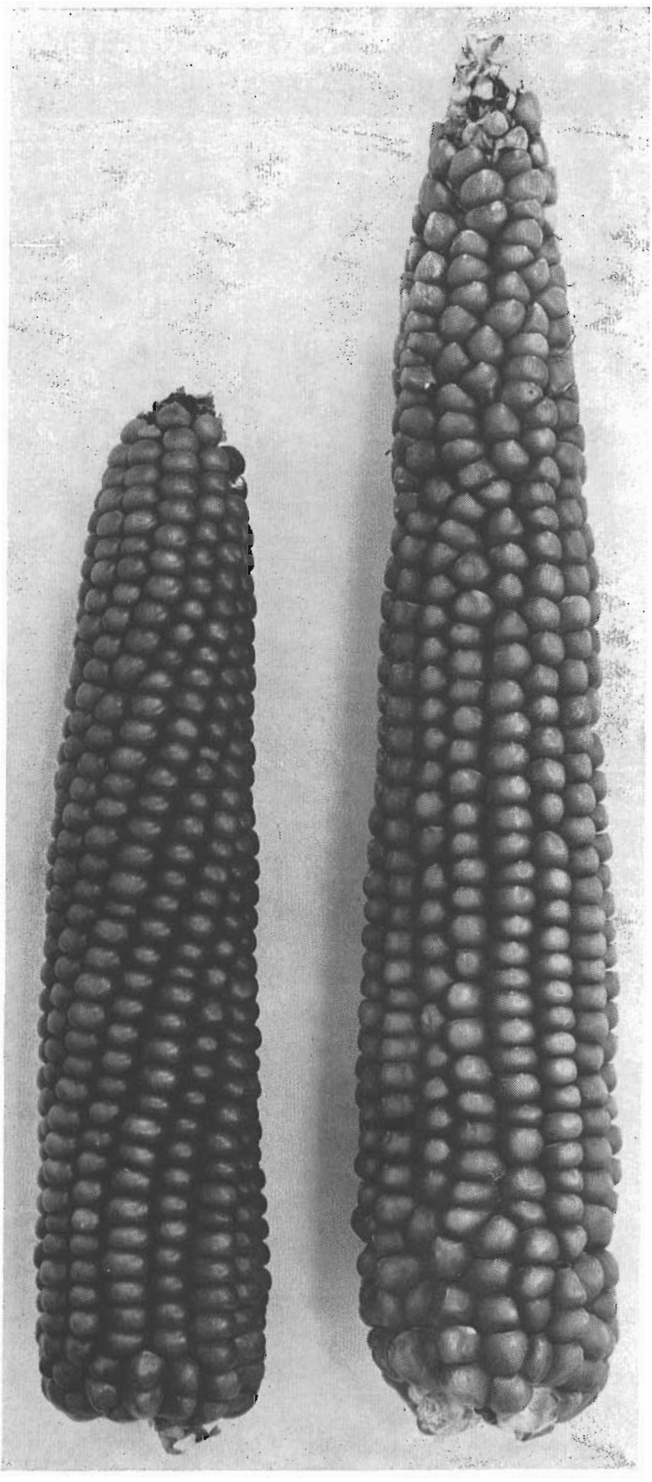


FIG. 180. Ears of Rienda showing two degrees of the effect of Perla gene flow into the populations of the former race. The ear at the left is very similar to Perla.

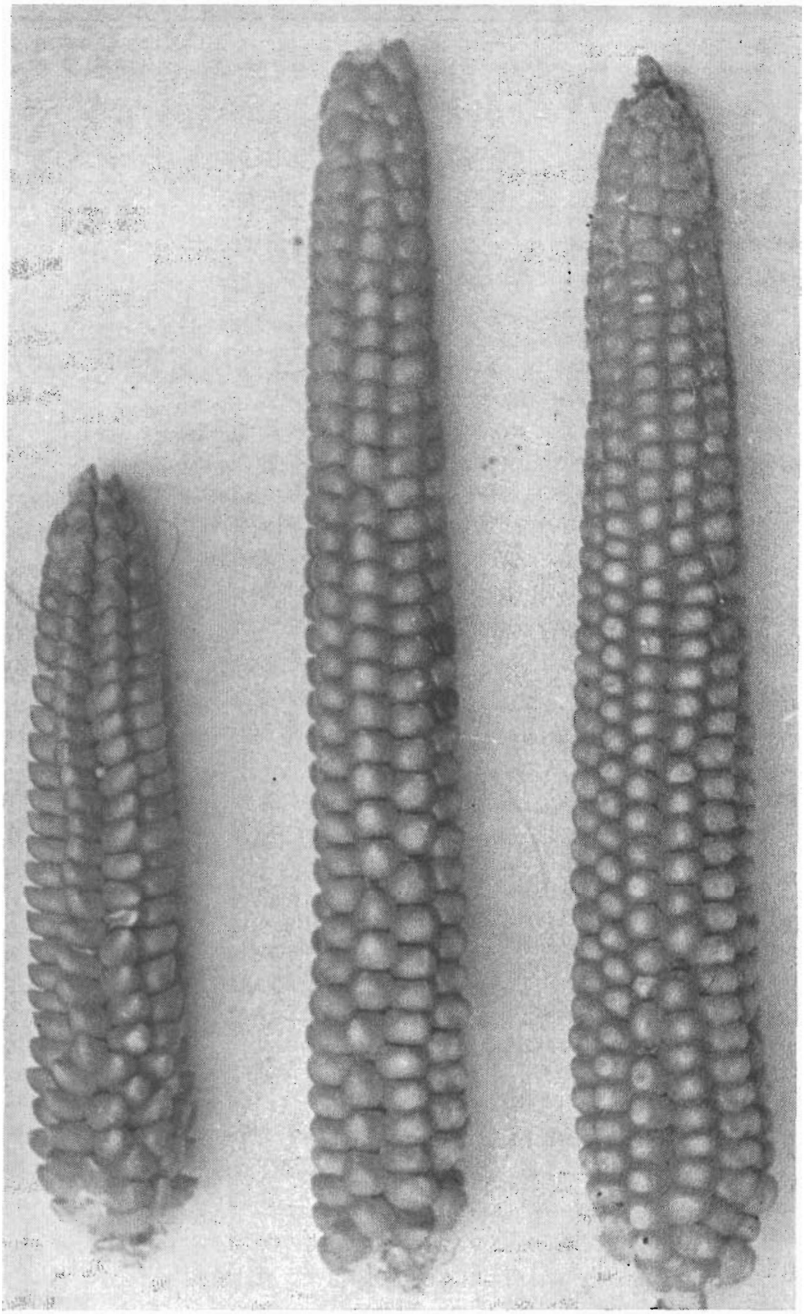


FIG. 181. Ears of Rienda (at right) shown in comparison with one ear of Confite Morocho (at left). The latter race is the ultimate ancestral precursor of Rienda. The ear of Rienda shown at the left center resembles closely some molded ceramic prehistoric ears from the North Coast.

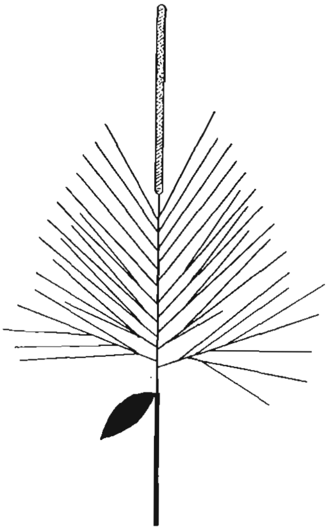


FIG. 182. Tassel diagram of Rienda.

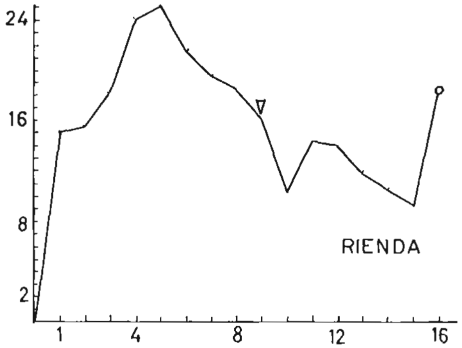


FIG. 183. Internode pattern of Rienda.

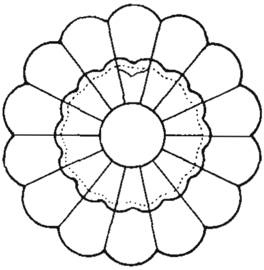


FIG. 184. Ear-cross-section diagram of Rienda.

that Rienda was confined in pre-historic times, as it is today, to the North Coast of Peru. It is found today in the Nepeña and Casma valleys in the Department of Ancash, and to a limited extent in the Viru valley, Department of La Libertad. It is probable that in past times it extended further north as far as Lambayeque. This race is now on the verge of extinction.

Origin and Relationships. A very plausible hypothesis for explaining the origin of Rienda is a direct derivation from Rabo de

TABLE 16. Comparison of Rienda with its Postulated Parental Races Rabo de Zorro and Perla.

	Rabo de Zorro	*Rienda*	*Perla*
Plant Characters.			
Height of Plant (cm)	171	274	225
Ear Height (cm)	90	184	130
Number of Leaves	11.8	14.0	13.7
Leaves above the Ear	5.2	6.0	5.6
Length of Leaves (cm)	61.1	70.6	94.4
Width of Leaves (cm)	8.7	9.1	10.6
Venation Index	2.78	2.64	2.50
Stalk Diameter (mm)	18.2	26.1	23.7
Days to Midsilk	115	113	97
Tassel Characters.			
Tassel Length (cm)	32.8	43.3	39.3
Length of Branching Sp. (cm)	15.6	20.8	16.5
Percent of Branching Sp.	47.6	48.0	42.0
Number of Primary Branches	16.0	20.5	20.8
Number of Secondary Branches	12.6	19.3	8.0
Number of Tertiary Branches	1.5	0	0.6
Condensation Index	1.04	1.05	1.07
Length of Peduncle (cm)	16.0	19.0	12.1
Ear External Characters.			
Length of Ear (cm)	18.45	16.90	18.53
Diameter of Ear (cm)	3.98	3.47	4.98
Row Number	10.40	14.00	15.64
Shank Length (cm)	8.14	—	7.17
Shank Diameter (cm)	1.12	—	1.56
Kernel Length (mm)	12.79	9.50	9.80
Kernel Width (mm)	7.90	7.20	8.80
Kernel Thickness (mm)	5.69	4.60	5.00
Ear Internal Characters.			
Cob Diameter (mm)	17.8	18.5	31.2
Rachis Diameter (mm)	8.2	8.5	19.1
Rachilla Length (mm)	1.8	3.6	3.1
Cob/rachis Index	2.17	2.17	1.63
Glume/kernel Index	0.42	0.53	0.62
Rachilla/kernel Index	0.15	0.38	0.32
Cupule Length (mm)	3.2	3.4	2.1
Cupule Width (mm)	4.6	4.1	9.2
Cupule Depth (mm)	1.8	1.6	1.6
Cupule Pubescence	1.31	1.90	1.25
Upper Glume Length (mm)	4.8	4.8	5.3
Lower Glume Length (mm)	5.7	5.1	7.4
Height Rachis Flaps	1.62	1.45	1.80
Rachis Induration	3.06	2.90	3.73

Zorro, as a low-altitude geographical variation. We have, as stated formerly, evidence of the presence of such an early Proto-Rienda variation of Rabo de Zorro in the Mochica Period on the North Coast. An archaeological ear from Huaca de la Cruz in the Viru Valley, in Dr. Towle's collection, is undoubtedly Rabo de Zorro or its derivative Proto-Rienda. Later, with the development of Perla, hybridization of this race with Proto-Rienda took place to give present day Rienda.

In support of this hypothesis we may refer to Table 16, where it may be seen how closely Rienda and Rabo de Zorro resemble each other in several characters, particularly the internal ear structure. Rienda, Rabo de Zorro, and other races ultimately derived from Confite Morocho, feature a slender cob, a high cob/rachis index and long and narrow cupules. In characters in which Rienda deviates from Rabo de Zorro, it approaches Perla. Rienda is intermediate between both postulated parents or is not different from one or the other parent in 18 characters; exceeds both parents in 12 characters, of which nine are of plant and tassel, indicating heterosis of vegetative characters, and it is smaller in 8 character values than both parents. It is especially interesting to note, too, the high chromosome knob number of Rienda with a distribution of knob positions following the pattern of Perla.

Derivation of Name. From the local name given to this race in the Casma valley. In Nepeña it is also known as Rabo de Zorro (fox tail), on account of the extreme flexibility and length of the ears.

MARANON

Plants (Fig. 187). Very tall, reaching sometimes up to 4 meters; late, averaging 166 days to maturity at 3,200 meters, and 122 days to 2,800 meters above sea level, the latter altitude being more comparable to that of its local habitat; number of leaves intermediate, 11.7, intermediate in length, and moderately wide; leaf area medium, 4,903 sq. cm.; venation index intermediate; ear position on the eighth node, above midway on the stalk; stalk extremely wide, sometimes as much as 6 cm.; prop root development strong; tillers few; pubescence slight with soft hairs; plant color dilute sun red; susceptible to both rust and Helminthosporium; seedling color index low.

Cytological Characteristics. Small to medium knob intercalary on chromosome 7L, frequency 55.5%; medium-large intercalary knob on 4L, frequency 22%; most frequent total chromosome knob number 1, followed by 0, and next by 2; B-chromosomes were present in 5 out of 9 plants studied, one of such plants with 2 B-chromosomes, and the other four with one B-chromosome each.

Tassel (Fig. 186). Peduncle very short; tassel medium-long; branching space intermediate in length and comparatively large in proportion to tassel length; length of branches intermediate; number of primary and secondary branches intermediate; tertiary branches large, condensation index low, 1.03.

Ears, External Characters (Fig. 185). Long, cylindrical, to slightly cylindro-conical; average number of rows 15; long shank, fairly thick, with low number of nodes; medium number of husk leaves, 8; kernels intermediate in their three dimensions, with surface depression almost nonexistant and slight striation, slightly beaked, but not showing imbrication; endosperm white, floury, and soft; aleurone color of the bronze and brown series may be present, interacting with pericarp colors to give the most bizarre appearances of any Peruvian corn race; midcob color brownish in 25% of ears, absent in 75%; glume colorless in 37.5%, colored red in 25%, and brown in 37.5% of ears; lemmas colorless in 25%, red in 25%, and brown in 50% of ears examined; pericarp and cob color frequencies: colorless-white 35.8%, variegated red-variegated red (AP^{vv}) 13.8%, brown-brown ($A^{b'}P^{rr}$) 11%, colorless-red (AP^{wr}) 6.4%, red-red (AP^{rr})and brown-white ($A^{b'}P^{rw}$) each with 5.5%, brown white cap-brown ($A^{b'}P^{cr}$) 4.6%, red white cap-red (AP^{cr}) 3.7%, and nine other less frequent combinations (Table 6A).

Ears, Internal Characters (Fig. 188). Average ear diameter 41.2 mm.; cob diameter 21.0 mm.; rachis diameter 12.1 mm.; pith diameter 5.3 mm.; estimated rachilla length long, 3.0 mm.; cob/rachis index medium-high, 1.73; glume/kernel index high, 0.38; rachilla/kernel index medium-high, 0.26; lower glume intermediate in length, in degree of pubescence, and in degree of hardness; upper glume intermediate in length, slightly pubescent, texture intermediate, venation low to intermediate; cupules medium-long, intermediate in width and depth, intermediate in degree of hairiness; height of rachis flaps low; rachis induration intermediate;

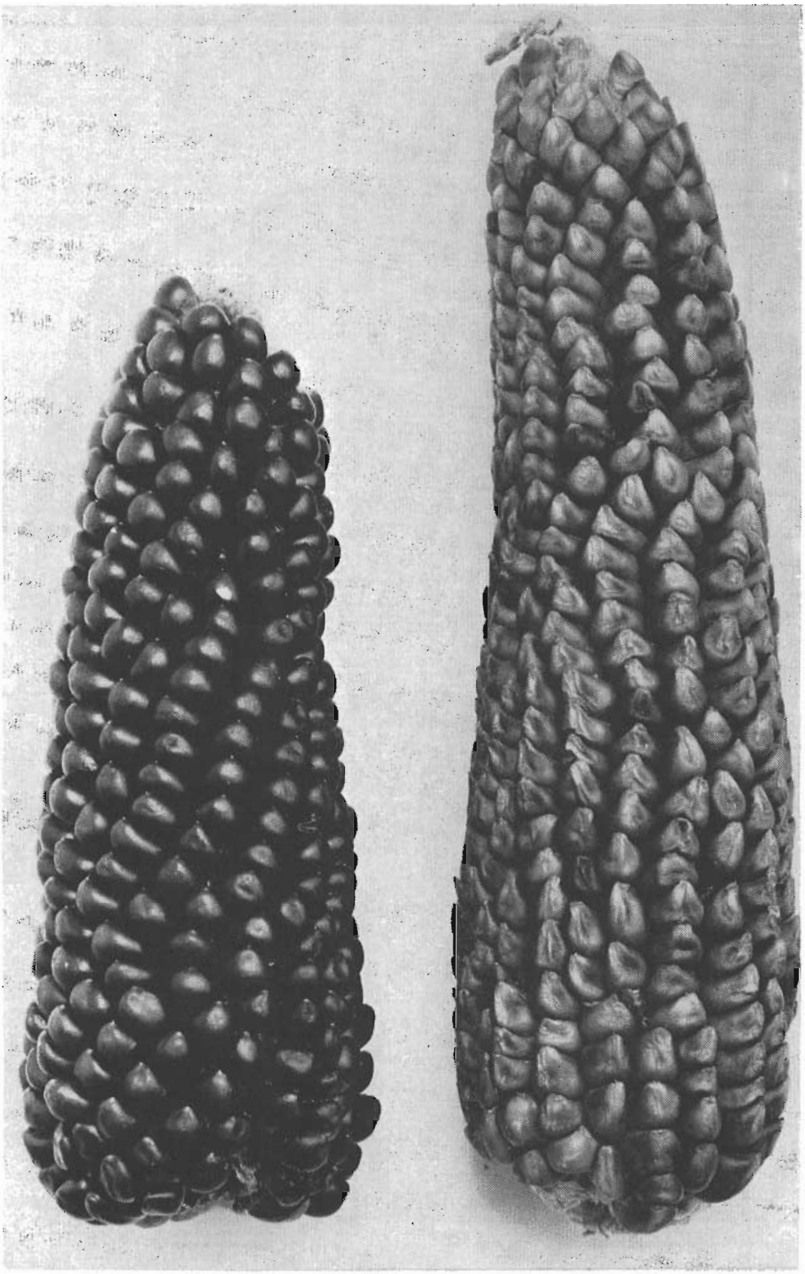


FIG. 185. Marañon (Lib. 50, and Lib. 70) ears showing the variation in this race.

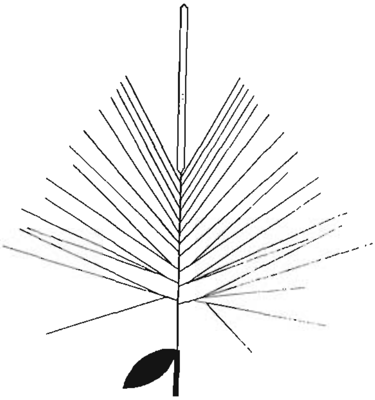


Fig. 186. Tassel diagram of Marañon.

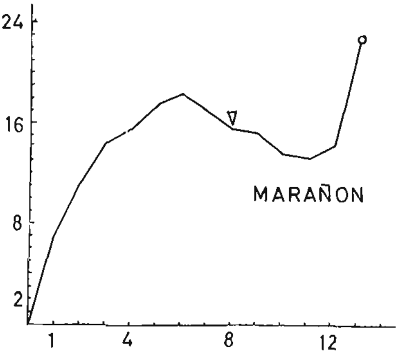


Fig. 187. Internode pattern of Marañon.

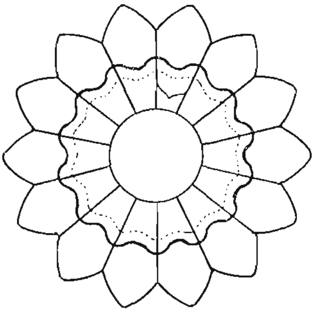


Fig. 188. Ear-cross-section diagram of Marañon.

tripsacoid characters have a minimum expression.

Distribution (Fig. 129). The area of dispersal of this race is the Marañon valley and its affluents in northern Ancash, northern Huanuco, and the southern part of La Libertad. It is grown at an average altitude of 2,700 meters, ranging from 2,000 to 3,000 meters above sea level. A sub-race of Marañon, Laurel, is found in the valley of La Convencion, Cuzco, at around 1,800 m. of elevation.

Origin and Relationships. Marañon is obviously derived from Rabo de Zorro, with which it has a sympatrical distribution. Ear characteristics of these two races are very similar and may be found gradating from one race into the other.

Marañon has on the whole larger ears and taller plants than Rabo de Zorro, and enough distinctive features to make it immediately recognizable as a different race. The development of the stalks of Marañon is extremely vigorous. In an experiment conducted in Cuzco for measuring forage yielding ability, one collection of Marañon gave 196 tons of green forage per hectare.

The differentiation of Marañon from Rabo de Zorro has undoubtedly been brought about by hybridization of the latter race with Ancashino (or alternatively with its derived race Shajatu) whose distributions border and overlap those of the other two races.

An examination of the ear cross-sections of these three races (Figs. 118, 128 and 188) shows Marañon intermediate between Rabo de Zorro and Ancashino. Internode length patterns follow similar trends in these races (Figs. 117, 127 and 187). In such internal ear characters as rachilla length, glume hardness and glume hairiness, Marañon approaches Ancashino, while in glume/kernel, and cob/rachis indices, glume characteristics, and cupule characteristics it falls within the range of average measurements of its putative parents.

Derivation of Name. From the Marañon valley region where this race has its center of distribution.

CHIMLOS

Plants (Fig. 191). Very tall, approaching 3.0 meters in their native habitat; extremely late, from 120 to 153 days, when grown on the Central Coast, depending on planting date; number of leaves large, 14.2; leaves long and wide, with a very large leaf area, averaging 10,770 sq. cm.; venation index low, 2.51; leaf pattern index, Quadrant II, 66%, Quadrant I, 33%; stalk thick, with strong prop root development; tillers very rare; pubescence score high with medium to soft hairs; ear position high, on the 10th node; plant color green; highly resistant to both rust and Helminthosporium leaf blight.

Tassels (Fig. 190). Peduncle relatively short; tassel length medium; branching space large; branches medium long, with primaries and secondaries in large numbers, medium number of tertiary branches; condensation index low.

Ears, External Characters (Fig. 189). Long, cylindrical, slender, and flexible, with an average number of 14 rows; shank short;

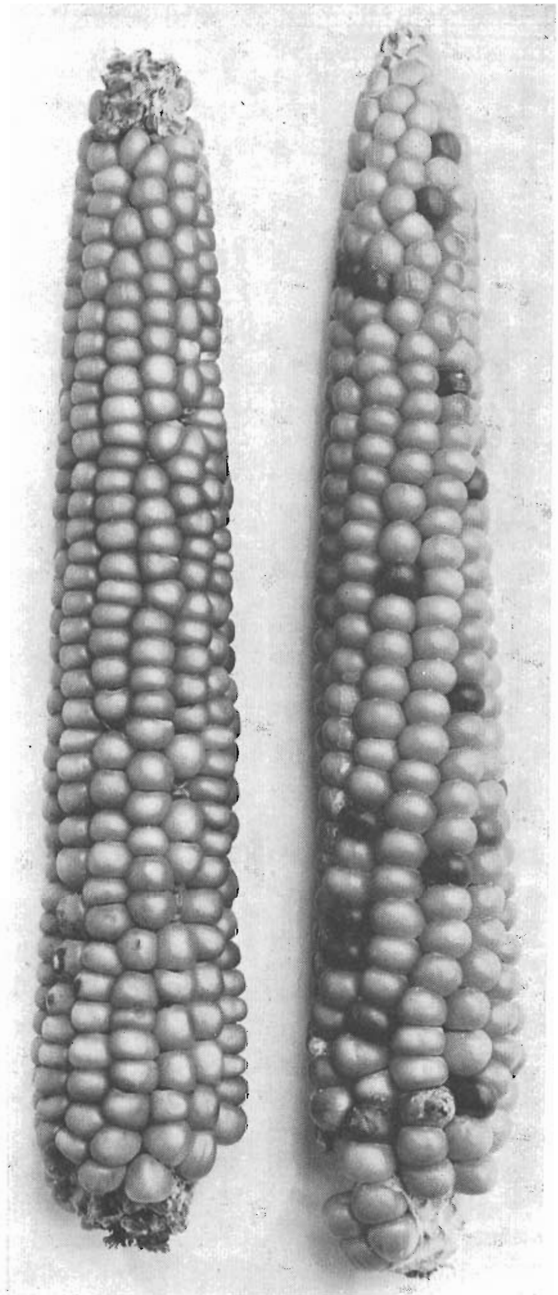


FIG. 189. Chimlos (Cuz. 108), typical ears. This is a race derived from Rabo de Zorro in the eastern lowlands.

medium-wide, with an intermediate number of nodes; medium number of husk leaves, 8; kernels small, round, short in length, medium in width, fairly thick, with smooth surface, weakly striated; endosperm yellow, flinty; midcob color reddish in 60% of ears; glume and lemma color red in 20%, colorless in 80% of ears; pericarp and cob color combinations: colorless pericarp-white cob 50%, red-red (AP^{rr}) 40%, variegated red-variegated red (AP^{vv}) 10%.

Ears, Internal Characters (Fig. 192). Average ear diameter 41.8 mm.; cob diameter 22.0 mm.; rachis diameter 11.6 mm.; pith diameter 4.75 mm.; estimated rachilla length medium, 2.8 mm.; cob/rachis index high, 1.89; glume/kernel index medium, 0.42; rachilla/kernel index medium, 0.22; lower glume of medium length, medium hairiness, and rather soft texture; upper glume medium to long, slightly hairy, soft, intermediate in degree of venation; cupules long, narrow, and medium deep to shallow, with intermediate hairiness; rachis flaps height medium, rachis induration high; tripsacoid characteristics present to a moderate extent.

Distribution (Fig. 193). Chimlos has not been found in its typical form outside of two main centers, the subtropical Urubamba valley in the La Convencion, Cuzco region, as well as in lateral small river valleys of the La Convencion system, and on the eastern Andean slopes of the Department of Huanuco, particularly in the upper Huallaga valley, near the city of Huanuco. In the La Convencion center, Chimlos, in its most typical form, has been found growing at an average elevation of 1,500 meters above sea level. At Huanuco it was collected at 2,250 meters.

It cannot be definitely stated whether Chimlos has a wider distribution than that found at present or not, since the middle Urubamba valley and the Apurimac river system, which lie between the two above mentioned centers, have not been explored for maize on account of their extreme inaccessibility.

Origin and Relationships. Chimlos is undoubtedly directly derived from Rabo de Zorro, like Piricinco, Rienda, and Marañon.

It shares with these races the extreme characteristics of Rabo de Zorro, modified to a limited extent: plant height, large leaf area, characteristic multipeaked internode pattern curve, long flexible cobs with high cob/rachis index, and characteristic long and narrow cupules.

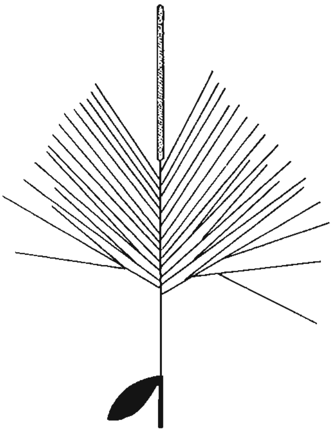


FIG. 190. Tassel diagram of Chimlos.

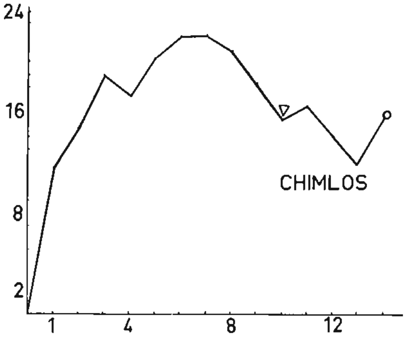


FIG. 191. Internode pattern of Chimlos.

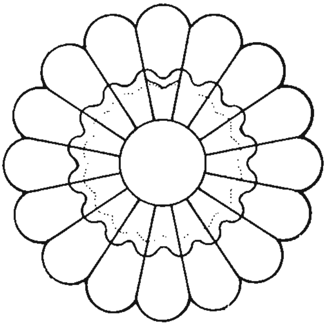


FIG. 192. Ear-cross-section diagram of Chimlos.

The flintiness of the kernels and the intermediate degree of Tripsacum influence in Chimlos, suggest that this race is a hybrid between Rabo de Zorro and a lowland race, which could well have been a precursor of the present day race Perlilla. The latter is, in turn, related to the group of South American tropical round seeded popcorns with long cylindrical ears, of which the described races Pira Naranja (Roberts *et al*, 1957), Pichinga Ihu (Brieger *et al*, 1958) and Pororo (Ramirez *et al*, 1960) are representatives.

Derivation of Name. From the local name most commonly applied to this race in the valley of La Convención.

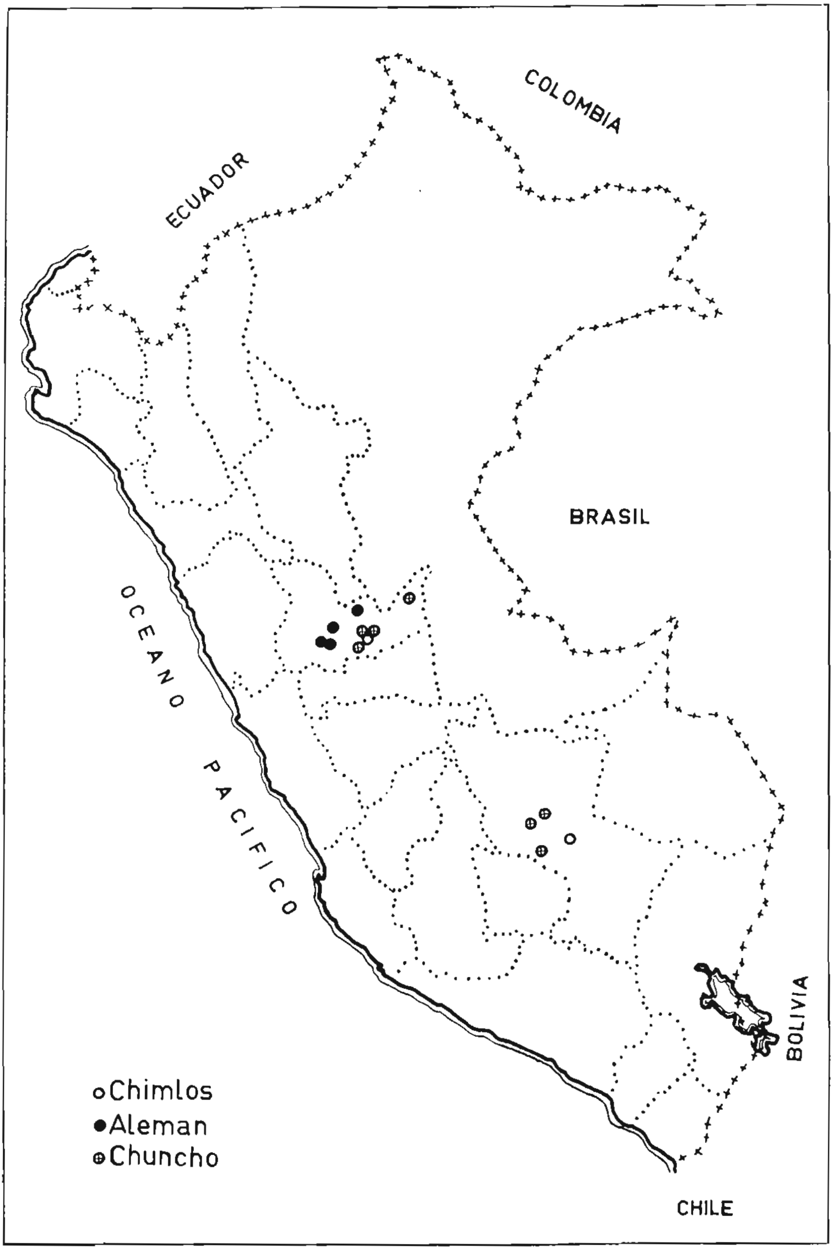


FIG. 193. Map showing the distribution of Chimlos, Aleman and Chuncho.

CUZCO GIGANTE

Plants (Fig. 196). Medium-tall, rather late; average number of leaves 10.5, of medium width and length, with large venation index of 3.0, and relatively large leaf area for high altitude races, 5,184 sq. cm.; stalk wide, without tillers, lacking pubescence; plant color dilute sun red; intermediate susceptibility to both rust and Helminthosporium; high seedling color index.

Tassels (Fig. 195). Peduncle intermediate in length, medium-long tassel with intermediate branching space; medium-long branches, intermediate in number; condensation index low, 1.01.

Ears, External Characters (Fig. 194). Medium-long, thick, elliptical, smoothly tapering to both ends; average row number 8.3; shank length short, medium-wide in diameter, with low number of shank nodes; intermediate number of husks, 7.3; kernels largest in overall size of any known race of corn, longest and widest of all Peruvian races, and very thick (average length 20.2 mm.; average width 16.2 mm., average thickness 6.0 mm.); slight to medium kernel depression, slight striation; endosperm white, floury, and soft; aleurone color usually absent; midcob color absent in 75% of ears, glumes and lemmas usually not colored; pericarp and cob color in the highly selected typical Cuzco Gigante of the Vilcanota Valley, with center in Yucay, colorless-white in almost all ears; however, a wider sample of Cuzco Gigante collections including the sub-races, Cuzco Gigante Morado, Cuzco Gigante Saccsa, and Cuzco Gigante Amarillo, give the following pericarp and cob color frequency: colorless-white 47.1%, red white cap-white (AP^{cr}) 9.1%, cherry-cherry ($AP^{rr}Plr^{ch}$) 8.3% variegated red-variegated red (AP^{vv}) 8.3%, red-red (AP^{rr}) 6.6%, red mosaic-red mosaic (AP^{mo}) 6.6%, colorless-red ($AP^{rr}Plr^{ch}$) 8.3% variegated red-variegated red (AP^{vv}) 8.5%, red-(AP^{rr}) 4.9%, brown-brown ($A^{b\prime}P^{rr}$) 3.3%, brown-white ($A^{b\prime}P^{rw}$) 2.5%, brown white cap-brown ($A^{b\prime}P^{cr}$) 1.7%, two other combinations (Table 6A) each with 0.8%.

Ears, Internal Characters (Fig. 197). Average diameter among largest of all Peruvian maize races, 56.8 mm.; average cob diameter 22.4 mm.; average rachis diameter 13.3 mm.; average pith diameter 4.2 mm.; estimated rachilla length short, 1.5 mm.; cob/rachis index medium-low, 1.68; glume/kernel index low, 0.22; rachilla/kernel index very low, 0.07; length of lower glume short; hairiness of lower glume quite marked, texture fairly hard; upper

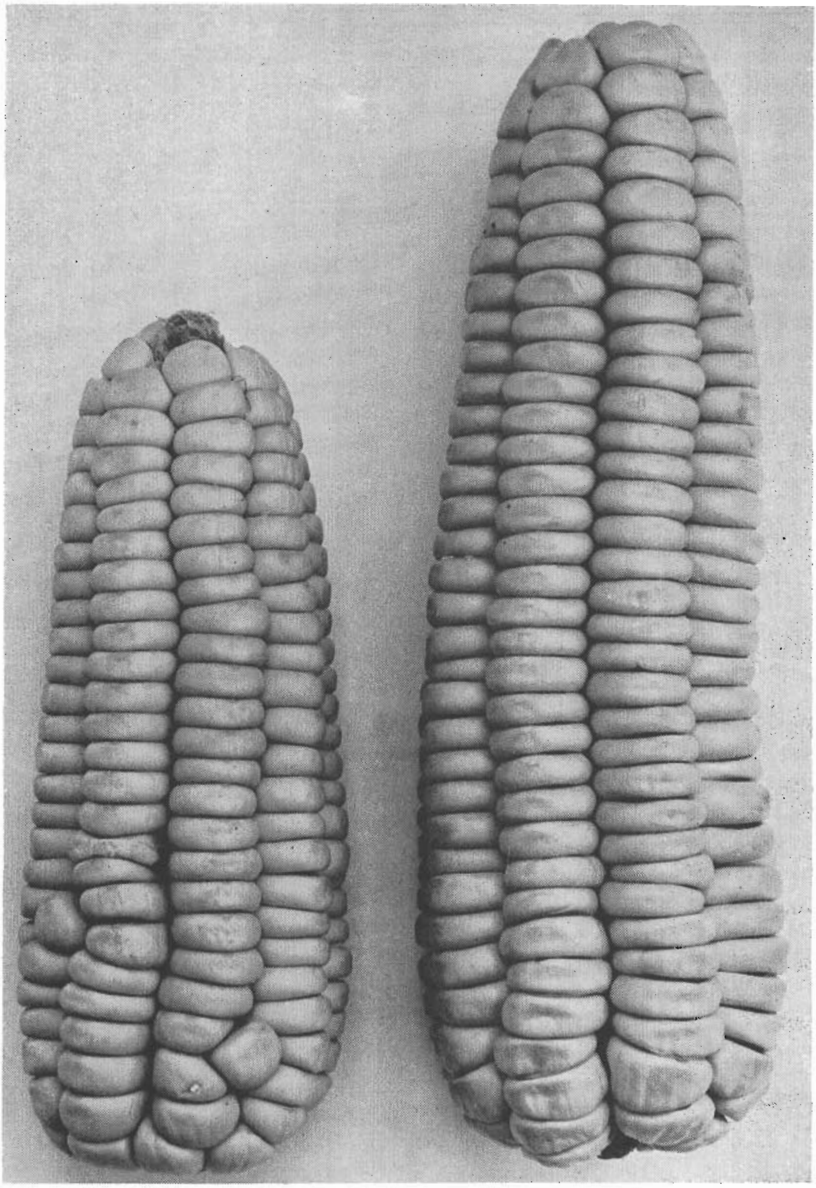


FIG. 194. Cuzco Gigante (Cuz. 98); typical ears. It has larger kernels than any other corn race. Its center of distribution is the Urubamba valley in Cuzco, at altitudes around 2,800 meters above sea level.

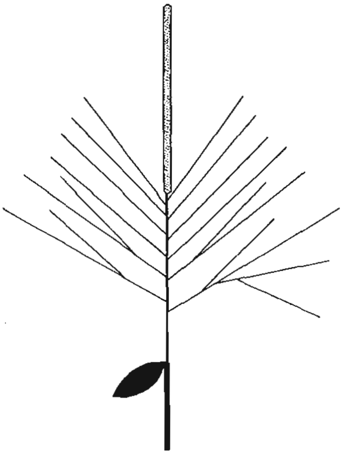


FIG. 195. Tassel diagram of Cuzco Gigante.

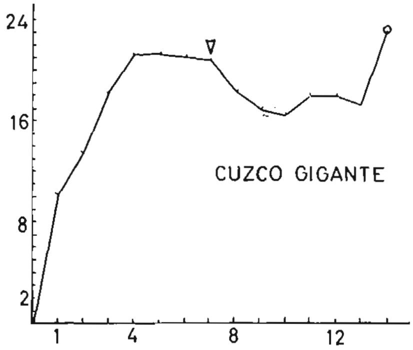


FIG. 196. Internode pattern of Cuzco Gigante.

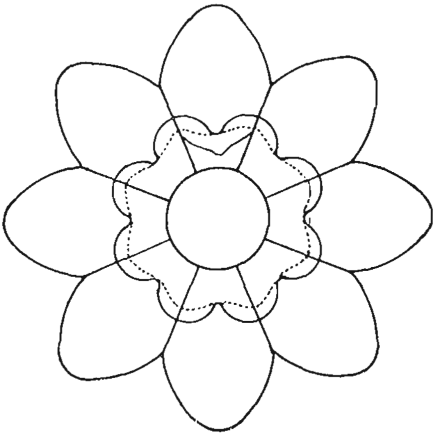


FIG. 197. Ear-cross-section diagram of Cuzco Gigante.

glume length intermediate, quite hairy, texture exceedingly hard, venation low; cupules short, of intermediate depth and very wide (widest among Peruvian races), exhibiting strong pubescence; rachis flaps height rather low; rachis induration intermediate; tripsacoid characteristics exhibited to an intermediate degree.

Distribution (Fig. 99). Cuzco Gigante has its central habitat in the Vilcanota valley of Cuzco, where it is grown at an average altitude of 2,800 meters above sea level, from Calca to Ollantaytambo. The largest and most productive varieties are grown in the vicinity of the villages of Yucay and Urubamba.

The conditions of the Vilcanota valley are ideal for corn growth. Warm days and cool nights, with temperatures not reaching the freezing points, availability of irrigation water, soils developed over calcareous mother rock, with good aggregation and neutral pH, supporting a "weedy" vegetation largely composed of the naturalized legumes, sweet clover (*Melilotus officinalis*) and bur clover (*Medicago hispida*), are factors of the environment under which Cuzco Gigante, one of the most highly evolved races of corn, originated. Under heavy fertilization and with population densities of 55,000 plants per hectare, farmers in the vicinity of Yucay attain yields of 10 tons of grain at 14% moisture per hectare.

In field experiments we have corroborated what local farmers have already known in regard to the distribution of Cuzco in the Vilcanota valley, that is, from Ollantaytambo up river, Cuzco Gigante outyields any other race including its semiflinty sub-race Cuzco Gigante Amarillo, while from Ollantaytambo down river, Cuzco Gigante Amarillo outyields Cuzco Gigante.

In the neighboring Department of Apurimac some Cuzco Gigante is also grown at altitudes comparable to those of the Vilcanota valley.

Origin and Relationships. The origin of Cuzco Gigante poses a problem, whose solution is tentatively given here.

Cuzco Gigante is undoubtedly a hybrid race, selected from the original Cuzco complex. The origin of the Cuzco race must have been in pre-Columbian times, perhaps paralleling the birth of the Inca Empire in the 13th century A.D. Evidence of the existence of a large-kernelled race of maize at the time of the Spanish Conquest comes from Cobo (1653) who states:

"Son muchas las diferencias que hay de maiz, porque primeramente se dan de todos los colores, blanco, negro y amarillo, morado, colorado claro y escuro, y mezclado de varios colores. Diferencianse ademas de esto en el tamaño de los granos; los mayores que se hallan son un poco menos que habas."

This original Cuzco corn was evidently far less evolved than the present Cuzco Gigante, although its extreme grain features were already developed to such an extent that it was recognized as an unusual and definite race (see Fig. 37).

To achieve the extremely large kernel dimensions in an 8-rowed-ear, Cuzco Gigante must have originated from two parental ancestors, both 8-rowed and already having large kernels.

The unusually high expression of hybrid vigor in Cuzco Gigante could be explained as coming from a wide racial cross, such as the hybridization of an 8-rowed original Cuzco, presumably a floury white endosperm counterpart of Cuzco Cristalino Amarillo, with Pardo, a low altitude 8-rowed floury race.

Pardo, a counterpart of the Mexican race Tabloncillo might have been introduced from Mexico to the coast of Peru in the Middle Post Classic Period or perhaps in the early Colonial Period. It is conceivable that highland raiders or traders could have then brought Pardo in to an area where it hybridized with the ancestral Cuzco form, and subsequent selection under the previously mentioned highly favorable environment of the Vilcanota valley, led to the present day characteristic phenotype of the race.

Cuzco Gigante shares with its related races Huancavelicano, Cuzco Cristalino Amarillo, Cuzco and Uchuquilla common morphological ear features, such as small rachilla length, very low rachilla/kernel index, low rachis diameter, similar glume dimensions, and a similar type of cupules.

In regard to glume and cupule pubescence, Cuzco Gigante exhibits high scores. Glume hardness is well above average for Andean races.

In external ear characters, Cuzco Gigante is definitely heterotic as compared to the modern forms of the postulated parents. In tassel characters it is intermediate, while in plant characters it approaches more the Cuzco Cristalino Amarillo phenotype, but is intermediate in height, leaf number, and leaf area.

Selection has proceeded to a point where in some populations a "genetic variability plateau" has been reached. This is evidenced by the reduced variability for interracial combining ability which has been observed for this race.

Derivation of Name. From the characteristic gigantism of the kernels of this race, largest of any maize race. Previous names found in the literature are: *Zea mays* var. *macrosperma* Kl and *Zea mays var. Cuzcoensis* Kcke. (Kornicke and Werner, 1885), Cuzco (Cutler, 1946), and Paraccai-Sara (Herrera, 1941).

CUZCO GIGANTE SUB-RACES

SACCSA

This sub-race differs from pure Cuzco Gigante in that it has ears selected for a characteristic broad red variegation streak pattern in the pericarp (Fig. 198).

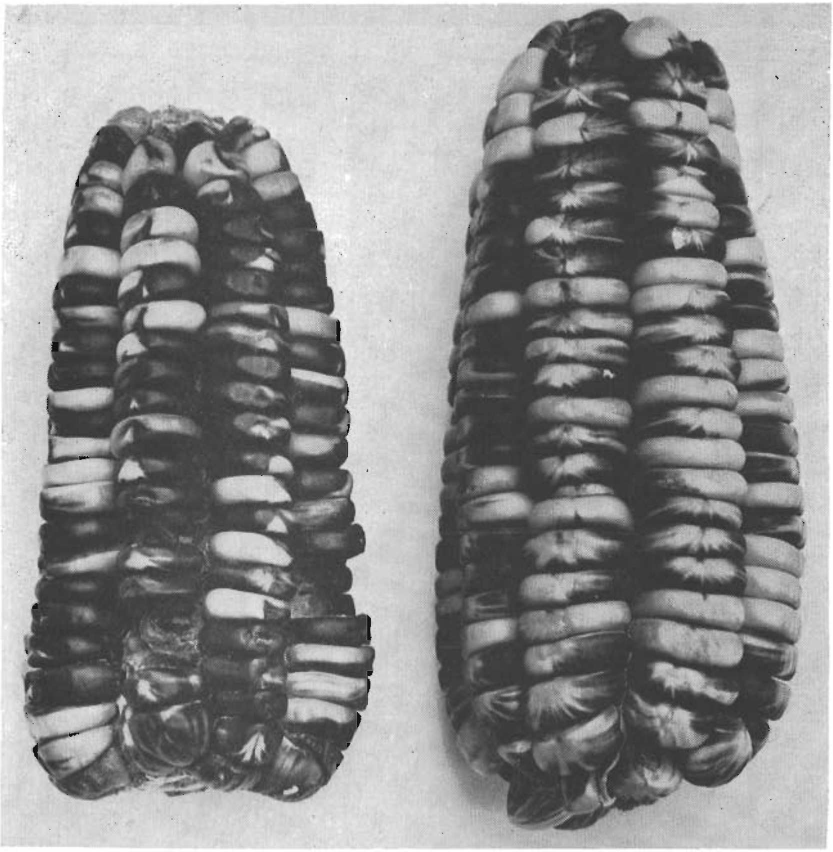


FIG. 198. Saccsa (Cuz. 94); typical ears. This is a sub-race of Cuzco Gigante selected for pericarp variegation.

The name Saccsa refers to the usual Quechua language denomination for variegated pericarp. Sometimes the name "Peruvian Saccsa," is also applied to Saccsa corn in Cuzco in reference to the broad red and white streaks of the pericarp, which are similar to the colors of the Peruvian flag. This sub-race corresponds to *Zea Mays var. mirabilis* Kcke., in the classification of Kornicke and Werner (1885).

CUZCO GIGANTE AMARILLO

A sub-race which is in an incipient process of formation down river from Ollantaytambo in the Urubamba valley. It is a semiflint race, with ear dimensions approaching those of Cuzco Gigante.

This sub-race appears to be a newly formed, still segregating, hybrid product between Cuzco Gigante, and Cuzco Cristalino Amarillo.

CUZCO MORADO

Selections of Cuzco Gigante for purple plant color, cherry pericarp and sometimes purple aleurone $A_1A_2BPlr^{ch}$ are grown in the Vilcanota valley and in garden plots at intermediate to high altitudes throughout the Sierra region (Fig. 199).

The fact that at least 6 of the 10 chromosomes (Chromosomes 2, 3, 5, 6, 9, and 10) of corn are involved in conditioning the

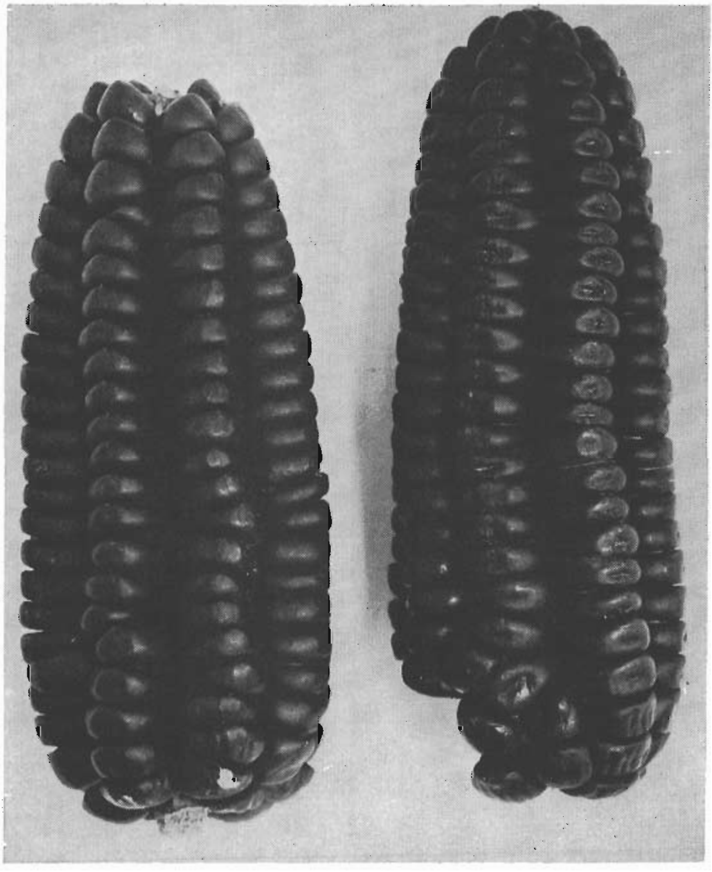


FIG. 199. Cuzco Morado (Cuz. 89); typical ears. This is a sub-race of Cuzco, characterized by smaller ears and deep cherry-black pericarp color, used for dyeing food.

color combinations in this sub-race, indicates the extent of genetic differentiation from the original Cuzco Gigante type. Such a differentiation appears to have been brought about through selection of Cuzco Morado to conform closely to a parental cherry pericarp-purple plant form of Huancavelicano which exhibited the characteristic star-shaped cross section of the ears of Huancavelicano, due to its very conspicuous longitudinal depressions between kernel rows. It is well to recall at this time that the latter race is believed to be derived from Kculli, the ancestral Andean cherry-purple race.

Cuzco Morado is employed in the preparation of either fermented or unfermented *chicha* or corn beer, and as one of the ingredients of *mazamorra morada,* a dyed fruit and tapioca jelly, popular primarily on the coast.

Morado Canteño, an incipient race of the Sierra of Lima is derived from Cuzco Morado.

HUAYRA CUZCO

A sub-race characterized by dusty chocolate or brown pericarp. The name *Huayra* refers to wind in the Quechua language, implying a dusty color.

INTRODUCED RACES

PARDO

Plants (Fig. 202). Medium-tall; medium late, requiring 99 days to mid-silk; large number of leaves, long and of medium width, with low venation index; large leaf area averaging 8,077 sq. cm.; stalk thick, with relatively weak prop root development, lacking tillers or with few infrequent ones; green plant color selected for as a specific racial distinctive feature; highly resistant to rust and Helminthosporium; seedling color index zero, lowest among Peruvian maize races.

Cytological Characters. Chromosome 7L one knob subterminal, occasionally large or very small, present with a frequency of 90%, of which in turn 12.5% are heterozygous; chromosome 6L subterminal small knob 22%, half of whose frequency corresponds to a heterozygous condition; most frequent total knob number one; no B-chromosomes present.

Tassels (Fig. 201). Peduncle short; length of tassel largest of

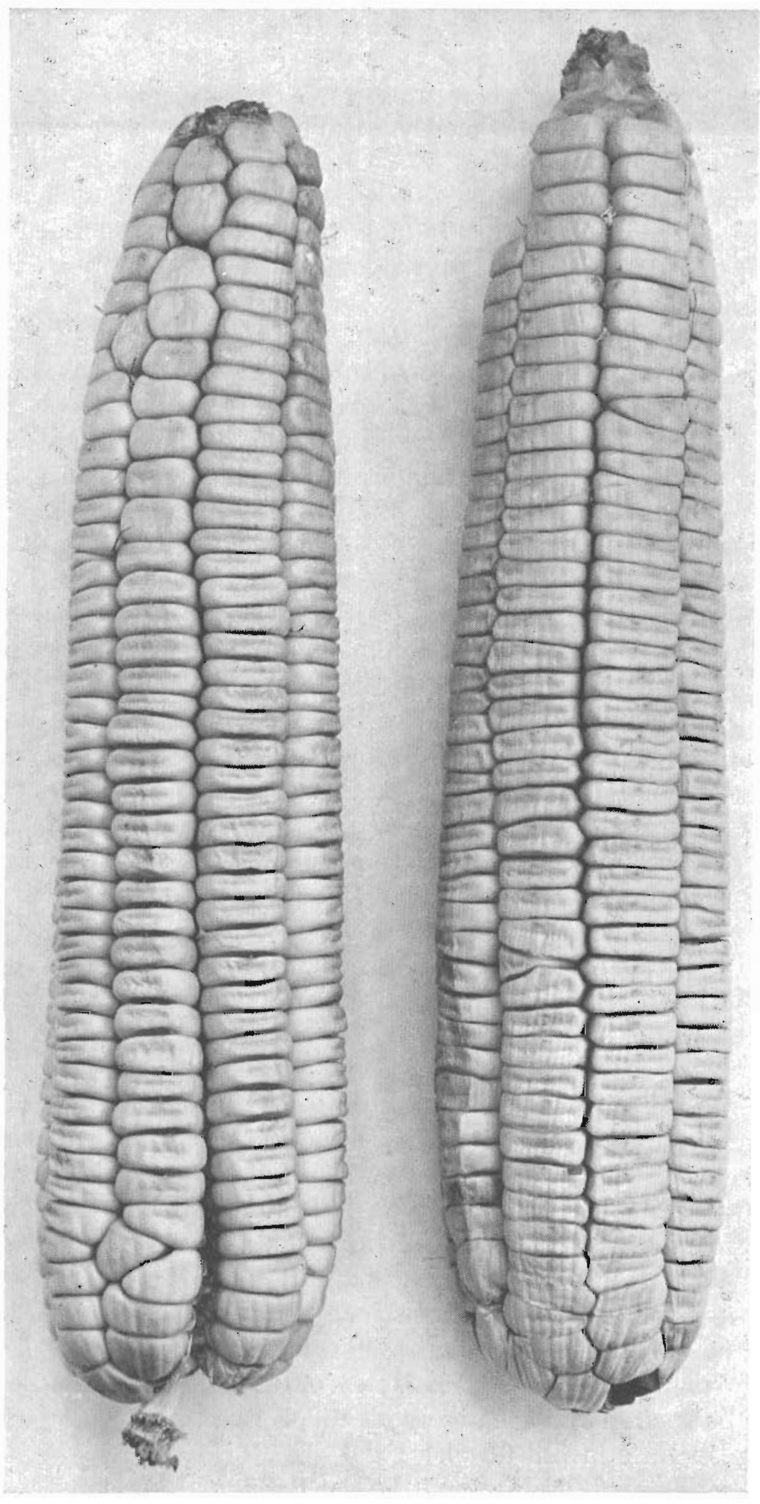


Fig. 200. Pardo, typical ears. This race is likely to be derived from the hybridization of the race Tabloncillo, introduced from Mexico, with Cuzco, on the Central Coast, shortly before or after the Spanish Conquest. (Compare with Fig. 45 and Fig. 83 of Wellhausen *et al,* 1952).

all Peruvian races, due mostly to a particularly long terminal spike; long branching space, 17.7 cm.; intermediate in proportion to total tassel length, 38.8%; extremely long branches, longest among Peruvian races; low number of primary and intermediate number of secondary and tertiary branches; condensation index low, 1.0.

Ears, External Characters (Fig. 200). Long cigar shaped, with slight taper at both base and tip, 8 rows; long shank, intermediate in width, with large number of internodes; kernels flat, intermediate in length and thickness, but very wide with medium to strong denting, strong striations; endosperm white, floury, and soft; no aleurone colors present; midcob color absent in 100% of ears; glumes white in at least 70% of ears; lemmas white in 100% of ears examined; all ears had colorless pericarp and white cob.

Ears, Internal Characters (Fig. 203). Average ear diameter 38.6 mm.; cob diameter 20.6 mm.; rachis diameter 12.0 mm.; pith diameter 4.1 mm.; estimated rachilla length short, 1.2 mm.; cob/rachis index medium, 1.71; glume/kernel index medium-low, 0.35; rachilla/kernel index low, 0.10; lower glume medium in length, sparsely pubescent, hard; upper glume of medium length and pubescence, soft, venation low; cupules intermediate in length, but wide and shallow and with marked hairiness; height of rachis flaps medium; rachis induration high; tripsacoid characters expressed to an intermediate to large degree.

Distribution (Fig. 169). Pardo is confined to the coastal valleys of the Department of Lima, particularly the Chancay, Huaura, Chillon, Lima and Pativilca. It is grown exclusively for use as green corn (on the cob). Its growing season is restricted to the cool, humid winter days, from April to October, when low overhanging clouds decrease the light intensity to ⅓ to ⅕ of full sunlight for nearly 20 days every month. Pardo is not adapted to spring or summer plantings on the Central Coast, or to winter plantings outside the region of low clouds, which extends from the valley of Huarmey to the valley of Cañete.

Origin and Relationships. Its long slender ear with large kernels, its very large, drooping tassel, colored green like the plants, are pronounced diagnostic characters of this race. A field of Pardo may be spotted and accurately identified from miles away, when the plants are in full tassel.

The origin of Pardo cannot be yet definitely ascertained. On

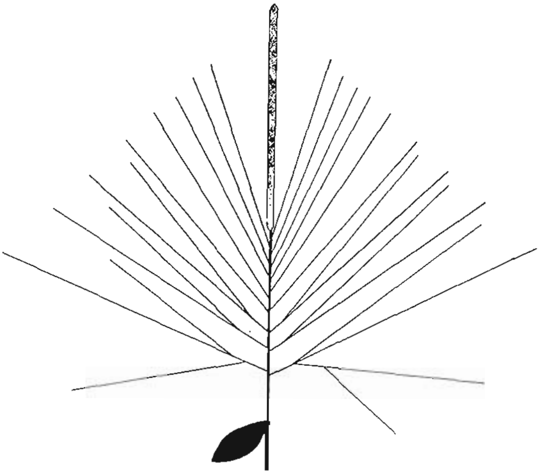


FIG. 201. Tassel diagram of Pardo.

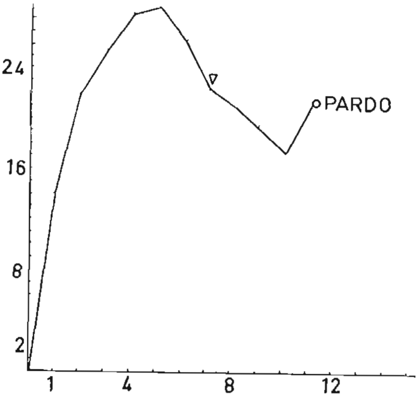


FIG. 202. Internode pattern of Pardo.

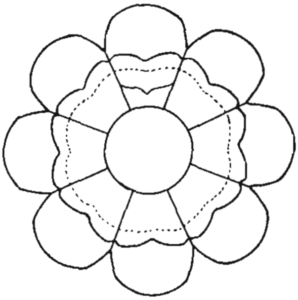


FIG. 203. Ear-cross-section diagram of Pardo.

the one hand Tabloncillo and Harinoso de Ocho, described by Wellhausen *et al*, (1952) as "exotic pre-Columbian Mexican races" greatly resemble Pardo in morphological features, such as ear and kernel type, tassel characters, low leaf venation index, expression of tripsacoid characters, in resistance to rust, and adaptibility to low elevations. On the other hand, Pardo shares several major characteristics with Cuzco and related Andean races, among them ear row number, general ear appearance, type of cupules, internode pattern of stem, low number and typical Andean positions of chromosome knobs and adaptation to lower average temperatures during the growing season. Pardo has, furthermore, been successfully grown at intermediate altitudes in the Andes. It would appear, therefore, that present day Pardo perhaps could have been derived from the introduction of Tabloncillo—which approaches Pardo in various morphological characters—into the Coast of Peru. The time of this introduction would have to be placed either in the late Inca Period or more probably shortly after the Spanish Conquest, since no archaeological evidence of a race like modern Pardo has been procured in Peru. This corn was likely carried by galleons from the west coast of Mexico. Oviedo (1535) mentions in this connection that toasted maize meal was a popular food among Spanish navigators shortly after the Conquest. Viable seeds of Tabloncillo, left over from food supplies, could have been the starting point of Pardo in Peru.

An inconsistency found in this hypothesis would seem to be the fact that Tabloncillo has been reported with a range of numbers of chromosome knobs of 7 to 9 (Wellhausen *et al,* 1952), while the range in Pardo is only 0 to 2. The reduction of number of knobs in Pardo, its flouriness, and general resemblance to Cuzco corn, could be explained by the hybridization of Tabloncillo and Cuzco on the Coast of Peru, and further selection for the present day characteristics of Pardo.

Early segregating populations of Pardo may have found their way back to the Vilcanota valley of Cuzco in Spanish Colonial times and gave rise to the extreme Cuzco Gigante race.

Other races derived from Pardo on the Peruvian Coast were Huachano and Chancayano, and through the latter, Jora, and the incipient race Chancayano Amarillo.

Derivation of Name. Pardo is the generalized name for this race. It means in Spanish brownish, but no definite correlation other than several highly personalized interpretations have been advanced as to its origin. Perhaps in former times it had a smoky brownish pericarp color, as its postulated ancestor Tabloncillo still posseses today.

ALEMAN

Plants (Fig. 206). Medium-tall, averaging from 99 to 104 days to mid-silk date depending on planting dates (at La Molina); number of leaves large; length and width of leaves medium-large;

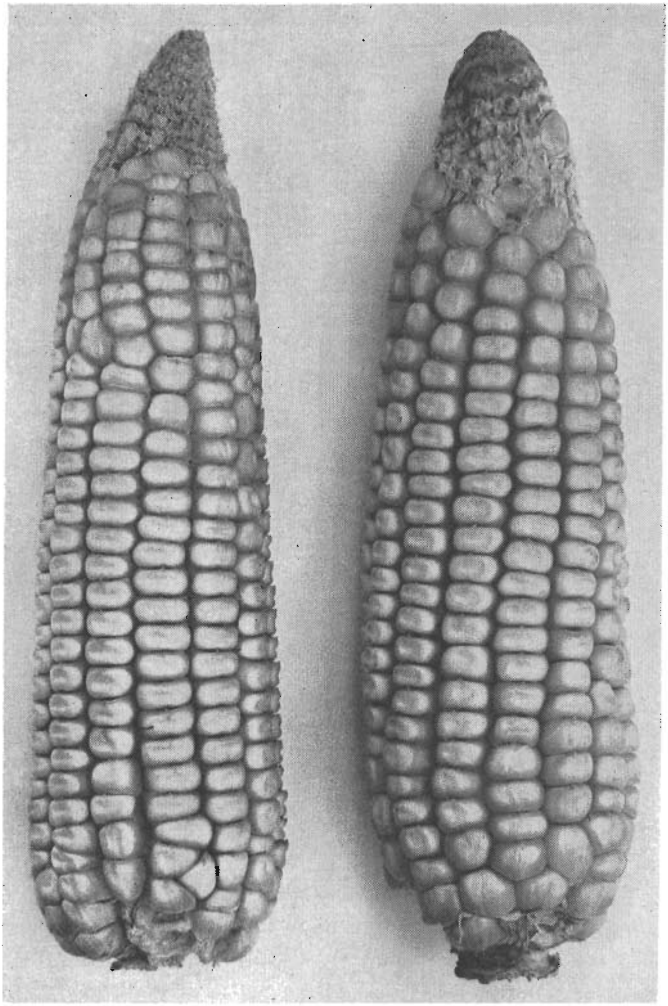


FIG. 204. Aleman (Sn. Mtn. 14); typical ears. This race was introduced to the eastern lowlands by German settlers in the second half of the last century. It belongs in the Tuxpeño complex.

leaf area medium-large, 6,746 sq. cm.; venation index high, 219; ear position medium-high on seventh node; stalk wide, with very strong prop root development, (largest score among Peruvian races); tillers short and few, if present at all; plant color frequently green; pubescence slight with hairs of medium coarseness; rust and Helminthosporium resistance high; relatively high seedling color index.

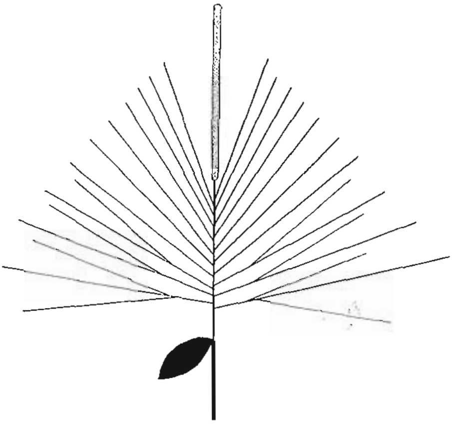


FIG. 205. Tassel diagram of Aleman.

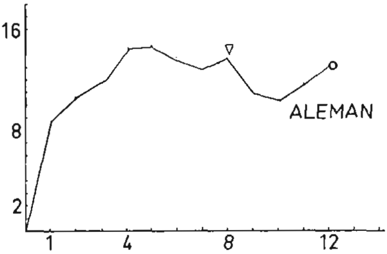


FIG. 206. Internode pattern of Aleman.

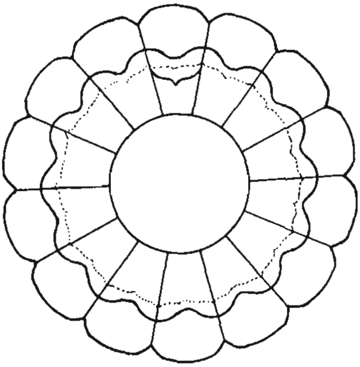


FIG. 207. Ear-cross-section diagram of Aleman.

Tassels (Fig. 205). Peduncle length short; tassel length medium, branching space medium; long branches; large number of primary branches, intermediate number of secondaries, small number of tertiaries; condensation index low, 1.07.

Ears, External Characters (Fig. 204). Medium-long, cylindrical; average row number 13; shank intermediate in length and wide; number of husks large; kernels of medium dimensions with limited denting and slight striations; endosperm white, corneous, hard; aleurone colors rare; midcob colors 60% light red, 30% brownish, 10% colorless; glumes and lemmas non-pigmented in 90% of ears; pericarp colorless and cob white in all ears examined.

Ears, Internal Characters (Fig. 207). Average ear diameter

46.9 mm.; cob diameter 29.0 mm.; rachis diameter 18.6 mm.; pith diameter 6.0 mm.; estimated rachilla length large, 3.1 mm.; cob/rachis index low, 1.56; glume/kernel index medium, 0.47; rachilla/kernel index high, 0.28; lower glumes very long, with medium hairiness, horny, hard; upper glumes very long with marked hairiness, intermediate texture, extraordinarily strong venation; cupules short, wide, deep, and moderately hairy; unusually high rachis flaps, most conspicuous among Peruvian races; rachis induration very high; tripsacoid characters strongly expressed.

Distribution (Fig. 193). Aleman is distributed in the subtropical valleys of the Departments of Huanuco and Pasco, its influence being encountered as far east as the Palcazu river. It is grown in a range of altitudes from 700 to 2,200 meters.

Origin and Relationships. Aleman is a race recently derived from the corn introduced during the last half of the nineteenth century by German settlers in the Oxapampa, Perene, and San Ramon colonies. This original corn was undoubtedly a variety of the race Tuxpeño of Mexico and the Caribbean area, which has had wide diffusion throughout the world.

A comparison of cross sections of the ear types of Aleman and Arizona (Figs. 207 and 215) and the observation of other similarities in biometrical measurements (Tables 2A to 8A) establishes with all certainty their very close relationship. Arizona is a later introduction of the Tuxpeño group to the Peruvian coast.

There is very little doubt that Aleman has experienced some genetic modification in the nearly one century since its establishment in the eastern Andean lowlands. From a comparison with Arizona, a related race, which has not been long enough in Peru to be greatly modified by local races, it may be seen that the cob of Aleman is thinner, its leaf area larger, prop root development stronger, stem internode pattern different (Figs. 206 and 214), all pointing to the introduction of a Rabo de Zorro—Piricinco gene complex into Aleman. Selection for ear type has maintained Aleman, however, very close to its original Tuxpeño type.

Derivation of Name. Aleman, (meaning German) refers to its origin as an introduction made by the German settlers in Peru.

CHUNCHO

Plants (Fig. 210). Very tall, very late, averaging 181 days to mid-silk date, when planted on the Coast (winter season); number of leaves high, 14.9, wide and long; large leaf area; venation index intermediate; stalk thick, with strong prop root development; tillers absent; hairiness medium-low; plant color dilute sun red; relatively high resistance to rust and Helminthosporium.

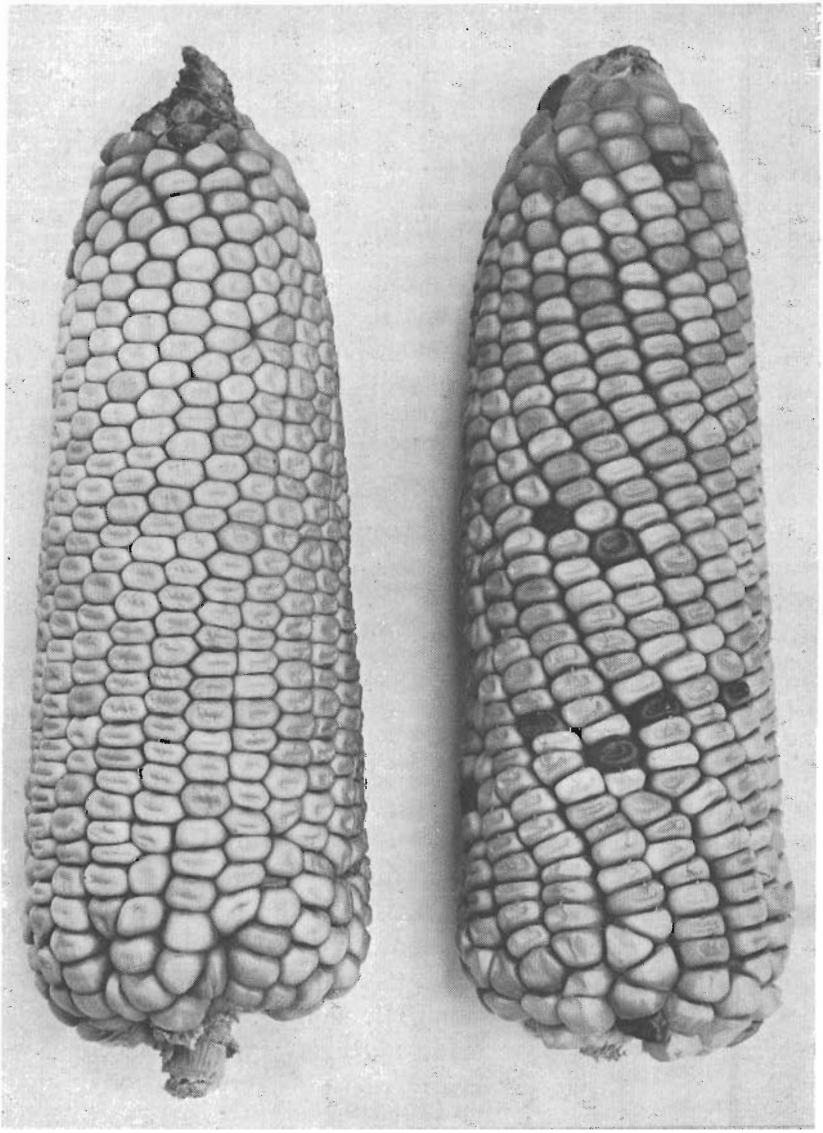


FIG. 208. Chuncho (Cuz. 118); typical ears. This race originated from a Caribbean or Colombian dent corn introduction to the La Convencion sub-tropical valley around 1870, after it had hybridized with local races.

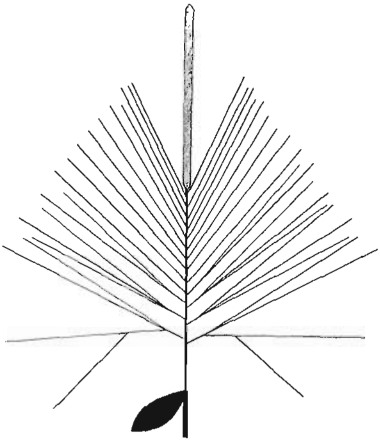


FIG. 209. Tassel diagram of Chuncho.

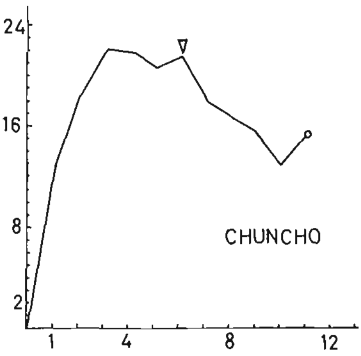


FIG. 210. Internode pattern of Chuncho.

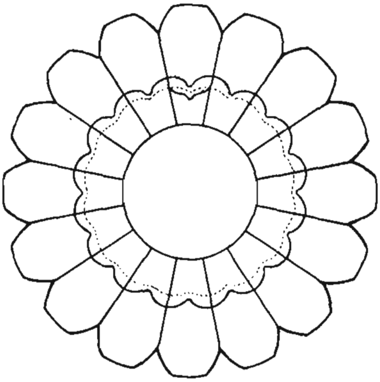


FIG. 211. Ear-cross-section diagram of Chuncho.

Cytological Characteristics. Subterminal knobs on the following chromosomes: 1S small knob frequency 20%; 1L large knob 40%; 2S medium knob 40%; 2L medium knob 40%; 3L either medium or very large knob 60%, with one additional position heterozygous on 3L 20%; 4S medium knob 40%; 4L large knob 60%, of which ⅓ are heterozygous; 5S medium knob 20%; 6L large to small knob 80%, of which one fourth are heterozygous; at least one additional position on 6L, 40%; 7L large to very small knob 80%, of which ¼ are heterozygous; 8L large to small knob 80%, with one additional position heterozygous on 8L 20%; 9L large knob 40%; terminal knob medium on 1L 20%; range in knob numbers from 5 to 11 per plant; at least seventeen different positions, five of them heterozygous at least once in five plants; no B-chromosomes were found in 6 plants examined.

Tassels (Fig. 209). Peduncle short; tassel length medium; branching space large; branch length medium-long; large number of primary, secondary and tertiary branches, condensation index low, 1.07.

Ears, External Characters (Fig. 208). Medium-long, cylindro-conical, thick, tapering to the tip; 16 rows; shank long and thick, with a large number of nodes; kernels intermediate in size, with strong denting, and slight surface striation; endosperm usually white, occasionally yellow, floury or corneous, soft to intermediate in hardness; a low proportion of ears exhibit slightly beaked kernels; pericarp and cob color combinations: colorless pericarp-white cob 48.8%, red white cap-white (AP^{cw}) 23.3%, red white cap-red (AP^{cr}) 18.6%, four other classes, each 2.3% (Table 6A).

Ears, Internal Characters (Fig. 211). Average ear diameter 49.5 mm.; cob diameter 29.1 mm.; rachis diameter 17.9 mm.; pith diameter 7.1 mm.; estimated rachilla length long, 3.2 mm.; cob/rachis index low, 1.62; glume/kernel index high, 0.44; rachilla/kernel index high, 0.25; lower glume length intermediate, pubescence low, texture horny, hard; upper glume long, sparsely haired, hard with intermediate venation; cupule length, width and thickness intermediate, strongly pubescent; high rachis flaps, rachis induration very strong; strong expression of tripsacoid characters.

Distribution (Fig. 193). Chuncho is grown in the subtropical valley of La Convencion in the Urubamba river system from north of Macchu-Picchu to El Encuentro. This and other corn races are grown there on steep valley slopes between 1,300 and 1,800 meters of elevation; the lower areas are reserved mostly for sugarcane, citrus, tea, etc.

Collections with characteristics similar to those of typical Chuncho have been found in the Department of Huanuco at altitudes ranging from 2,250 to 2,700 meters above sea level.

Origin and Relationships. Chuncho is a race which exhibits strong tripsacoid characteristics, far removed from those typical of the races of the South American central lowlands. Information was gathered in the valley of La Convencion, which indicated that during the last quarter century a Peruvian senator with land holdings in the La Convencion region imported a race of corn which natives still refer to as "Nueva Granada maize" (Herrera, 1941). Nueva Granada was the Spanish designation for the former Viceroyalty of Spain which comprised what is today Colombia, Venezuela and part of Ecuador.

Chuncho approaches in many characteristics races of the Tuxpeño group, and this consideration, coupled with the historical information, leads us to postulate that a white kernelled Tuxpeño type of corn from Venezuela or Colombia was introduced into the La Convencion valley. It underwent there extensive hybridization with the old sub-race Laurel, a derivative of Rabo de Zorro, which is very similar in ear and plant characteristics to Marañon.

An examination of the plant internode pattern diagrams, cytological characteristics (17 chromosome knob positions), and other plant, tassel and ear characters (Tables 2A to 8A) will show the evidence of such a relationship.

Derivation of Name. Chuncho is the Quechua name for the inhabitants of the Amazonian lowlands, and to things related to them. The term Chuncho is also widely used at La Convencion as the name of the race we are describing here.

ARIZONA

Plants (Fig. 214). Medium-tall; late, averaging 83 days to mid-silk in its habitat on the North Coast, and 98 on the Central Coast; leaves long and wide, but few in number, 10.5; leaf area intermediate, 5,800 sq. cm.; venation index low, 2.68; stalk wide, with moderate development of prop roots; tillers absent or rarely present; pubescence slight with hairs of medium coarseness; plant color green; moderate resistance to rust and Helminthosporium.

Cytological Characteristics. Chromosome knob positions and frequencies are as follows: subterminal knobs: 1S homozygous large 20%, heterozygous small 20%; 1L heterozygous small 20%; 2S homozygous medium to large 40%; 3S homozygous medium 20%; 4L homozygous medium 80%; heterozygous large 20%; 5L homozygous medium 20%; heterozygous small 20%; 6L medium 100%; additional knob 66%; of which 25% are heterozygous; 7L large to medium 100%, of which 16.6% are heterozygous; 8L small 33%, additional knob 16.5%; 9L large to medium 60%; terminal knobs: 7S medium 33%; 9S large to very small 82%; no

FIG. 212. Arizona (Lib. 16), typical ears. This race was introduced to the North Coast from the southern U. S. during this century. It is a derivative of the Tuxpeño group somewhat modified by Alazan.

B-chromosomes were present. Total number of knob positions at least 15; total number of knobs per cell from 6 to 8.

Tassels (Fig. 213). Peduncle short; tassel length intermediate; short branching space; length of branches medium; low number

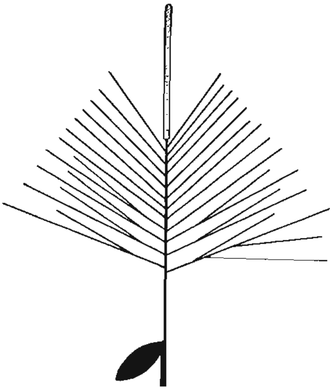


FIG. 213. Tassel diagram of Arizona.

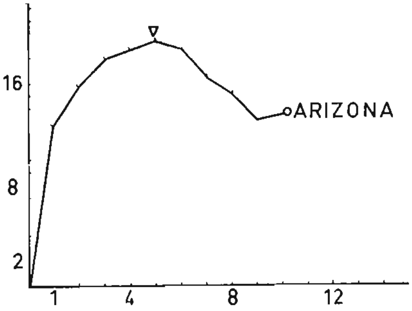


FIG. 214. Internode pattern of Arizona.

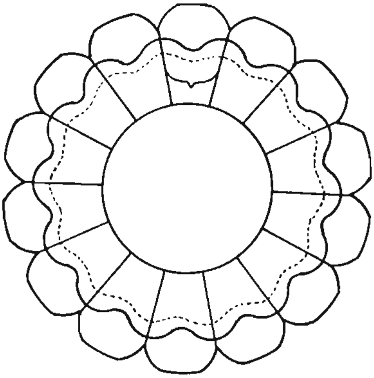


FIG. 215. Ear-cross-section diagram of Arizona.

of branches; condensation index low, but higher than other Peruvian races, 1.12.

Ears, External Characters (Fig. 212). Medium-long, broad, cylindrical, 14-rowed; shank medium in length, fairly wide, with large number of internodes; kernels wide, and of medium length and thickness, strongly dented with medium striations; endosperm corneous, hard; aleurone colors often absent, rarely purple; pericarp and cob color combinations: colorless pericarp-white cob 98%, colorless pericarp-red cob (AP^{wr}) 2%.

Ears, Internal Characteristics (Fig. 215). Average ear diameter 49.9 mm.; cob diameter 34.6 mm.; rachis diameter 23.4 mm.; pith

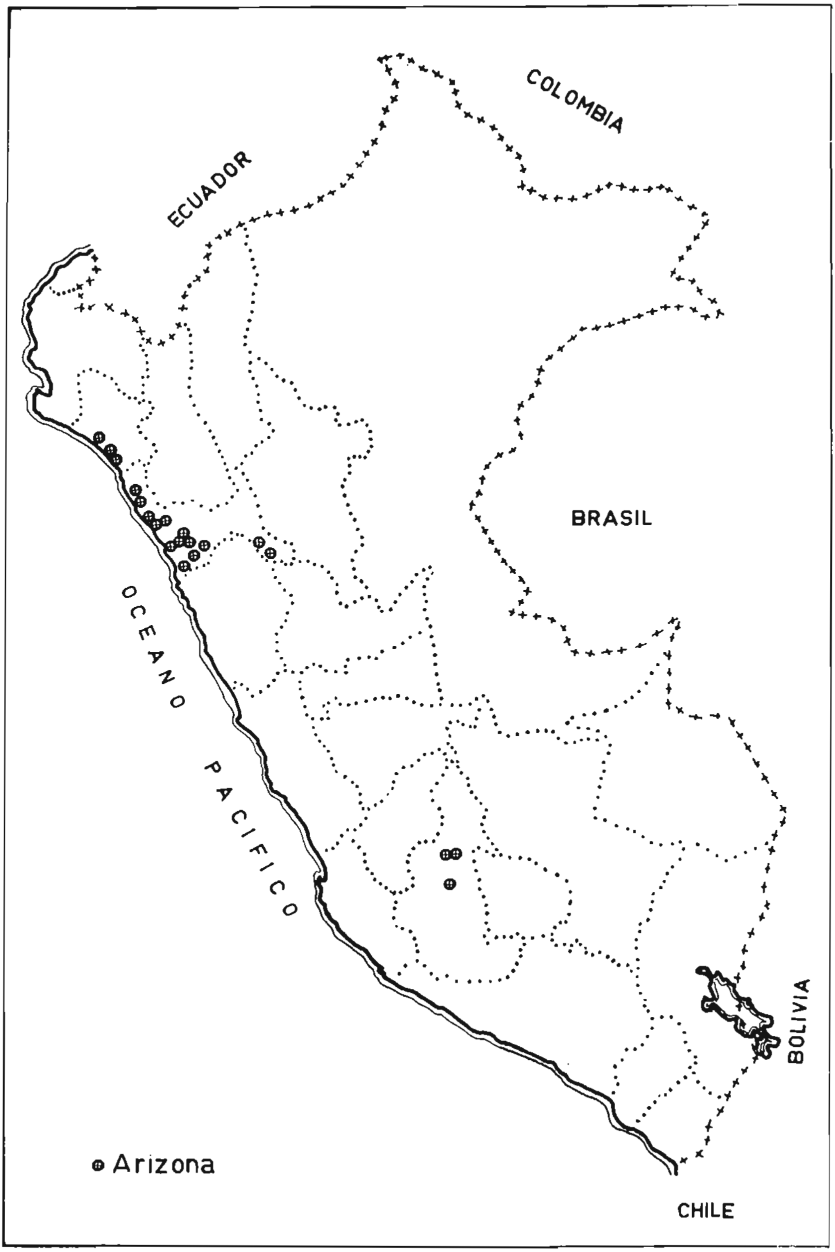


FIG. 216. Map showing the distribution of Arizona.

diameter 13.3 mm., the last three dimensions being respectively the largest among Peruvian races; estimated rachilla length short, 1.5 mm.; cob/rachis index low, 1.48; glume/kernel index medium, 0.48; rachilla/kernel index low, 0.13; lower glume long, with moderate hairiness, horny and hard; upper glume very long, hairy, texture hard, venation strong; cupules intermediate in length, very wide, intermediate in depth, pubescence intermediate; height of rachis flaps large; rachis induration strongest of all Peruvian races; tunicate allele *tu;* tripsacoid characters expressed to a considerable degree.

Distribution (Fig. 216). The center of distribution of Arizona is in all the valleys of the North Coast from Chao to the Pueblos region of the La Leche valley. Peripheral distributions have originated by migration from this area in more recent years and have extended the range of this race as far north as the Tumbes valley near the Ecuador border, as far east as the Marañon valley in the Department of La Libertad, and as far south as the Inter-Andean medium altitude zone at Huanta, Ayacucho (2,200 meters above sea level), and the valleys of Sihuas and Vitor in Arequipa.

Origin and Relationships. From time to time during the present century there have been introductions of Arizona as various forms of Tuxpeño germplasm. The most recent and important ones were made by the Peruvian Ministry of Agriculture from 1930 to 1942. Arizona has been grown together with Alazan primarily in the valleys of Viru and Moche; extensive hybridization has ensued between these two races, and intermediate forms of what could be called an incipient sub-race Colorado de Viru are becoming more prevalent than former Alazan. Colorado is characterized by its red pericarp ears of otherwise true Arizona type.

Derivation of Name. Arizona is the generalized name of the race, and refers obviously to the origin of the seed of recent introductions.

CUBAN YELLOW DENT

Beginning around 1942 introductions of Cuban Yellow Dent corn were made in the jungle and subtropical regions of the Huallaga valley by the Tingo Maria Agricultural Experiment Station. This race has spread rapidly in this area and other Amazon basin regions.

On the coast, definite varieties of Cuban Yellow Dent have been in commercial production for at least 15 years, and recently the newer hybrids being distributed in the North and Central Coast regions contain considerable germplasm from this source.

The plants are of medium to short stature, early, with ears at intermediate position on the stalk; the ears are medium sized, cylindrical, with 14 to 16 rows of large sized yellow dent kernels, usually with a prominent starchy cap.

This race has been accurately described in Cuba by Hatheway (1957).

INCIPIENT RACES

JORA

Plants (Fig. 219). Medium to tall; intermediate in maturity; large number of leaves, 13.5, which are long and wide; large leaf area, averaging 7,153 sq. cm.; leaf pattern index, 100% in Quadrant II; venation index medium-low, 2.62; ear placed midway on the plant, on the 7th node and at an average height of 1.32 m.; stalk thick with occasional tillers; well developed prop roots; green stalk color; leaf sheath pubescence slight with medium to soft hairs; resistant to both leaf blight (Helminthosporium and *Cercospora* sp) and to leaf rust.

Cytological Characteristics. Jora collections from their central habitat (Huarmey valley) and from Huanuco and La Libertad were found to have a large number of chromosome knobs varying from 4 to 11 per nucleus (4 to 7 in Huarmey). Knob positions in Huarmey collections (Ancash 9) are 2L subterminal, 3L subterminal, 4L subterminal, 6L subterminal, 7S terminal, 7L subterminal, 8L subterminal, 10S terminal, and 10L subterminal.

In addition, in the collections Huanuco 87 and Libertad 37 the following knob positions were found: 1S terminal, 1L subterminal, 9S terminal. Two knobs each were found in 6L, 8L, and 10L; no B-chromosomes were apparent.

Jora is the race in which the highest frequencies of chromosome 10 knobs have been found. The two other races, Perla and Alazan, where knobs on chromosome 10 are present are both related to Jora.

Tassel (Fig. 218). Medium peduncle; long tassel; long branching space, 17.2 cm.; very long terminal spike which makes the percentage branching space lower than in other coastal races,

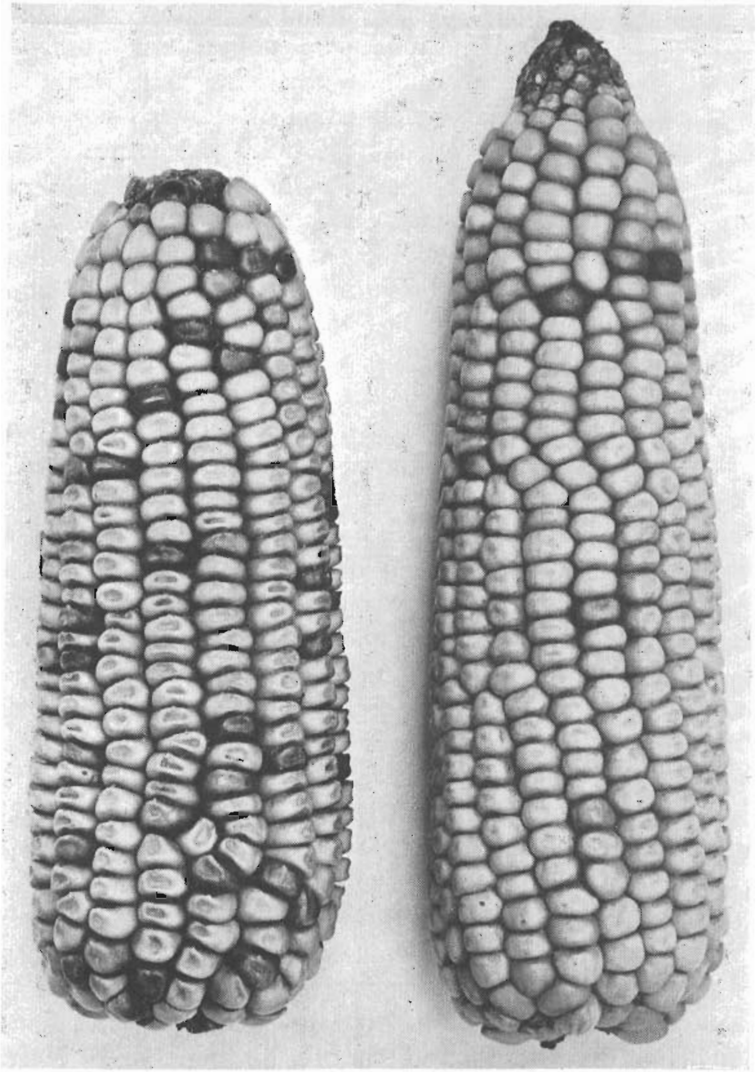


FIG. 217. Jora (Anc. 9); typical ears. This race is restricted to the Huarmey valley, on the Central Coast. It has a high incidence of abnormal chromosome 10.

39.4%; branches very long, with large number of primaries, and intermediate number of secondaries and tertiaries; condensation index low, 1.08.

Ears, External Characters (Fig. 217). Cylindrical, rather broad, medium length (about 17 cm.), tapering slightly toward the tip and rounded at the base; average number of rows 14.5; shank long and wide, with a large number of nodes; large number of husks, 12.5; kernels of medium length, wide and with rather small thickness; both surface depression of kernels and striation strong; endosperm color white, soft, starchy and corneous; aleurone color segregating purple and colorless, the purple being variable in intensity from light to dark (as phenotypes of a^{p1}, A^{b1} to A_1), midcob color absent in 80% of ears, glumes and lemmas not colored in 90% of ears, brown in the rest; pericarp and cob color frequencies: colorless-white 70%, colorless-red (AP^{wr}) 30%; occasional brown-brown ($A^{b\prime}P^{rr}$) ears are found.

Ears, Internal Characters (Fig. 220). Average ear diameter 50.1 mm.; cob diameter 31.0 mm.; rachis diameter 21.7 mm.; pith diameter 12.3 mm.; estimated rachilla length intermediate, 2.0 mm.; cob/rachis index low, 1.43; glume/kernel index low, 0.38; rachilla/kernel index low, 0.16; lower glume length medium, pubescence low, texture horny, hard; upper glume length medium, pubescence low, texture medium, venation strong; cupules short, intermediate in depth, and wide, with strong hairiness; rachis flaps height low; rachis induration medium strong; tripsacoid characters expressed to a considerable degree.

Distribution (Fig. 169). The center of distribution of Jora is the small coastal valley of Huarmey in the Department of Ancash. Outside of Huarmey, Jora is not grown to any great extent. Collections resembling it from other localities are very few and represent obviously modern migrant populations.

Origin and Relationships. Jora is presumably derived from the hybridization of Chancayano and Arizona in modern times. It is quite probable that a sub-race selected from Chancayano with a high frequency of purple aleurone was grown in the Huarmey and neighboring valleys long before the introduction of Arizona. This latter race, also white in endosperm color, yielding occasional purple kernels, and not different in general appearance from Chancayano, could have been mixed in plantings and so had a chance to produce hybrid ears with Chancayano, which on account of their greater weight and better appearance in later generations would have been easily selected.

Jora has knob positions similar to those of Arizona and an abnormal chromosome 10 situation, present in tripsacoid corn (Arizona is highly tripsacoid). The plant, tassel, ear and kernel

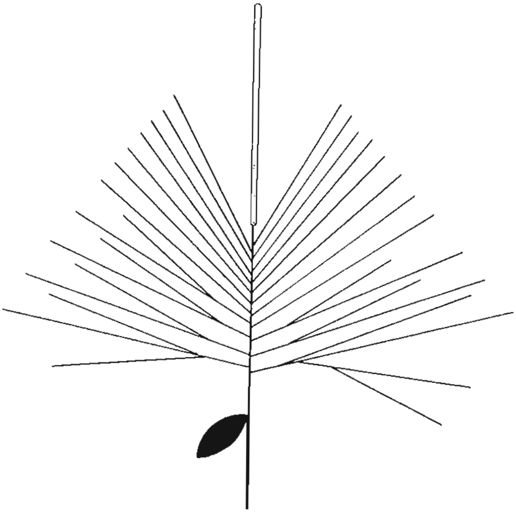


FIG. 218. Tassel diagram of Jora.

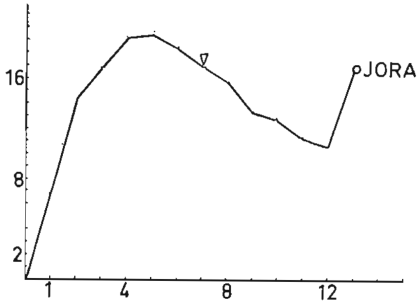


FIG. 219. Internode pattern of Jora.

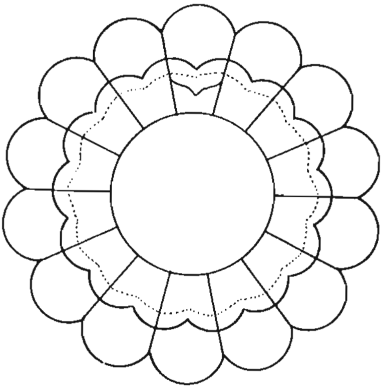


FIG. 220. Ear-cross-section diagram of Jora.

characteristics of Jora are intermediate between those of its putative parents.

There are indications that Jora populations may have had in the past some degree of contamination from Shajatu, a purple aleurone race, whose habitat is in the highlands of Ancash, not far from the Huarmey valley.

Derivation of Name. Although the Quechua word *Jora* literally means corn malt (germinated, then sun dried corn kernels for use in making *chicha*), it is the only name by which this race was known in Huarmey at the time collections were made in 1953. The name obviously refers to the main purpose for which grain from the race Jora is utilized. Even though we are aware of the general meaning of the term Jora, we propose it in a restricted sense as a particular racial designation on account of its extensive regional usage for such purpose.

CORUCA

Plants (Fig. 223). Medium-tall, late, averaging 98 to mid-silk at La Molina, but perhaps at least two weeks less in its local habitat in southern Peru; number of leaves large; very long and wide; leaf area large, average 8,140 sq. cm.; venation index very low, 2.1; ear position high on eighth node; stalk width medium-large; tillers absent; prop roots exhibit strong development; plant color green to dilute sun red; glabrous plants, susceptible to both rust and Helminthosporium.

Tassel (Fig. 222). Peduncle very long; tassel long; branching space very large both in length, 19.2 cm., and percentage, 49.2; branch length intermediate; number of primary, secondary and tertiary branches very large; condensation of tassel low, 1.0.

Ears, External Characters (Fig. 221). Medium-long, cylindro-conical, rather thick, average number of rows 10.6; shank very long, medium to thick, with a small number of nodes; kernels very long and wide, and intermediate in thickness; with very strong denting and surface striation and no imbrication; endosperm white, floury, soft, no aleurone color; midcob color absent in all ears examined; glumes colorless; lemmas colorless; pericarp and cob color combinations: colorless-white 50%; colorless-red (AP^{wr}) 16.6%, brown-brown ($A^{b\prime}P^{rr}$) 16.6%; variegated brown-white ($A^{b\prime}P^{vv}P^{ww}$) 16.6%.

Ears, Internal Characteristics (Fig. 224). Average ear diameter 57.0 mm.; cob diameter 22.2 mm.; rachis diameter 15.2 mm.; pith diameter 6.5 mm.; estimated rachilla length intermediate, 2.4 mm.; cob/rachis index low, 1.46; glume/kernel index low, 0.19;

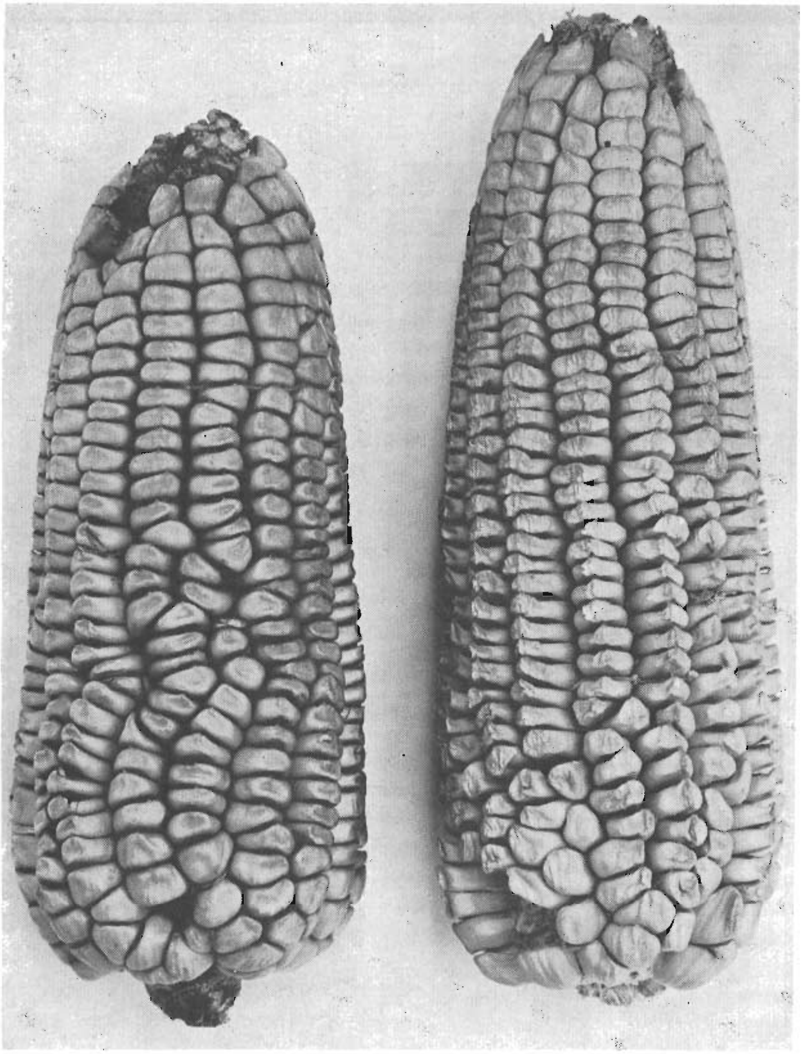


FIG. 221. Coruca (Tac. 3), typical ears. Coruca is related to Chaparreño through the common Chullpi influence on both races. It has, furthermore, Cuzco influence, as well as influence from U. S. Corn Belt dent through gene flow from its related maize Choclero, from Chile.

rachilla/kernel index low, 0.13; lower glume very short; highly pubescent, texture hard; upper glume very short, pubescence strong, venation very low; cupules short, wide, and shallow, with medium hairiness; height of rachis flaps low; rachis induration

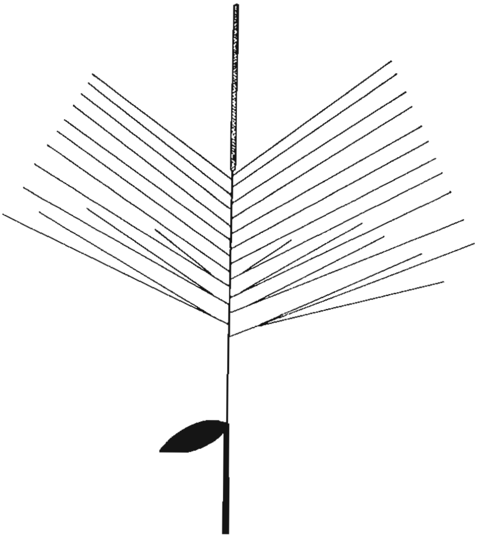


FIG. 222. Tassel diagram of Coruca.

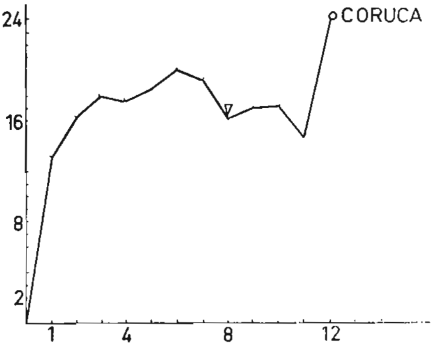


FIG. 223. Internode pattern of Coruca.

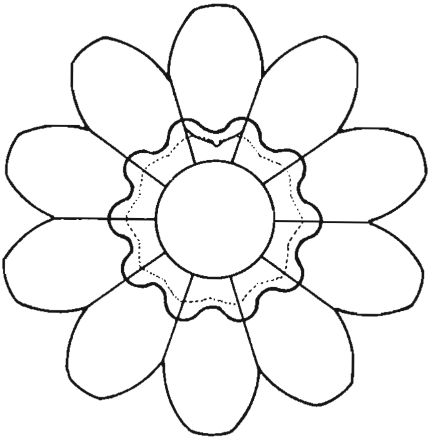


FIG. 224. Ear-cross-section diagram of Coruca.

medium-high; tripsacoid characters expressed with an intermediate intensity.

Distribution (Fig. 169). Coruca is limited to the irrigated coastal areas of the Department of Tacna where it is grown, particularly near the village of Tomasiri, and in the lower Locumba valley. A racial form similar to Coruca is cultivated in Chile where it is known as Choclero.

Coruca is used mostly as a green corn; it has very sweet kernels when in the milk stage.

Origin and Relationships. A comparison of Figs 197 and 224 immediately indicates the similarity in internal ear characters between Coruca and Cuzco Gigante. In the same way Figs. 196 and 223 show resemblances in internode growth pattern.

Both Coruca and its related race Choclero from Chile are selected segregates from hybrid populations where Cuzco Gigante, Chullpi, and an open pollinated Corn Belt dent variety of the U.S.A., introduced into Chile from Minnesota many years ago, are involved.

The collections of Coruca from Tacna are strongly hybridized with a sub-race of Arequipeño, grown locally in Tacna under the name Pachia, after the locality where it is centered. In fact, we have found near Tomasiri, Tacna, that Pachia, an earlier corn, is used for replanting areas with faulty seed germination in fields of Coruca, this practice enhancing hybridization between these two races. This is the reason why Coruca is much more Cuzcoid (Pachia being a typical Cuzco-like sub-race of the Arequipeño group) than its related form Choclero from Chile.

Derivation of Name. Coruca is the local name for the race described here.

MOROCHO CAJABAMBINO

This is an incipient race derived from Morocho and found at the northernmost limit of the distribution of the latter race in Peru, in the Departments of Cajamarca and Amazonas (Fig. 94).

Morocho Cajabambino has taller plants with a few more leaves than Morocho; its tassel has a shorter peduncle, but longer and more abundant branches than Morocho, and it is very similar in biometrical ear measurements (Tables 2A to 8A).

Morocho Cajabambino is sympatrical to the distribution of Sabanero in the Department of Cajamarca and blends into the latter race. Very often the only criterion of distinction remaining in some collections is the flintiness and yellow color of the kernels of Morocho Cajabambino.

This race is also known as Morocho Musha in the vicinity of Chachapoyas, Department of Amazonas.

MORADO CANTENO

Plants. Short, average height 1.30 m.; early; number of leaves short and intermediate, respectively; venation index high; stalk width intermediate, without tillers or prop roots, glabrous, colored purple or sun red; ear position midway on the plant; resistant to both rust and Helminthosporium.

Tassels. Peduncle length intermediate, tassel length intermediate, branching space short, long branches; number of primary and secondary branches small, no tertiary branches; condensation lacking, index 1.0.

Ears. Medium, cylindro-conical, 10-12 rows, average 10.9; peduncle slender; kernels intermediate in size; usually floury and soft, with no depression; cherry pericarp and purple plant color ($AP^{rr}Plr^{ch}$); glumes intermediate to soft in texture; rachis induration intermediate; slight to intermediate expression of tripsacoid characters.

Distribution. The present center of distribution of this race is along the Quebrada of the Chillon river, from Sta. Rosa de Quives to Canta, Department of Lima, at altitudes averaging 1,900 meters.

It is grown in small acreages at scattered locations in the narrowing middle altitude areas of the coastal valleys.

This race is used primarily as a dye corn for the preparation of *chicha morada,* a soft, fruit-flavored, purplish drink, and of *mazamorra morada* a jelly fruit pudding, typical of the Central Coast. The centers of consumption of Morado Canteño are Lima and secondarily other coastal cities.

Origin and Relationships. There is little, if any, doubt that Morado Canteño is a race derived from the sub-race Cuzco Morado with some gene flow from a lowland tripsacoid race, very likely Perla.

Morado Canteño has been strongly selected to maintain the cherry plant and pericarp color of Cuzco Morado, which is primarily derived from Kculli.

Derivation of Name. From its quality of being purplish and its center of distribution at the lower altitudes along the road leading to the town of Canta.

SARCO

Sarco is probably an incipient new race with characteristics of potentially high productivity. Its distribution is sympatric to that of Ancashino and extends toward the eastern lower areas of Ancash, progressing toward the Marañon valley.

The ears of Sarco are longer and broader than those of Ancashino, but maintain the characteristically strongly conical shape of the latter. The kernels of Sarco are floury, much larger than those of Ancashino, slightly beaked, often with pericarp colored brown or red, or colorless.

Its cytological characteristics are fairly simple. Only one small knob on 7L, homozygous, frequency 100% has been detected in 4 plants from 3 collections. No B-chromosomes were found.

Apparently introgression of a large kernelled race, such as Cuzco, has conditioned a vigorous expression of this new hybrid race, which approaches the phenotype of Ancashino very closely, as would be expected from its overlapping distribution with the latter parental race.

Sarco is represented by a fairly large number of collections from Ancash.

Nothing is known as to the meaning of its generalized designation.

IMPERFECTLY DEFINED RACES

AJALEADO

A few collections from the highlands of eastern Ancash showed an ear phenotype totally different from other known local races (Fig. 225). We are calling it Ajaleado.

Ajaleado closely resembles the Caingang floury dents described by Brieger *et al* (1958), and the type specimens of Cholito from Bolivia (Ramirez *et al,* 1960). The ears are medium-long, broad, with a large number of rows, and a superficial appearance of interlocking.

Nothing conclusive can be said about this group of maize biotypes. The answer to the question as to whether or not they are migrants segregating within local populations of other races, incipient new forms originated by hybridization, or marginal representatives of the Caingang or Cholito groups, will necessarily have to wait until additional material is collected and studied.

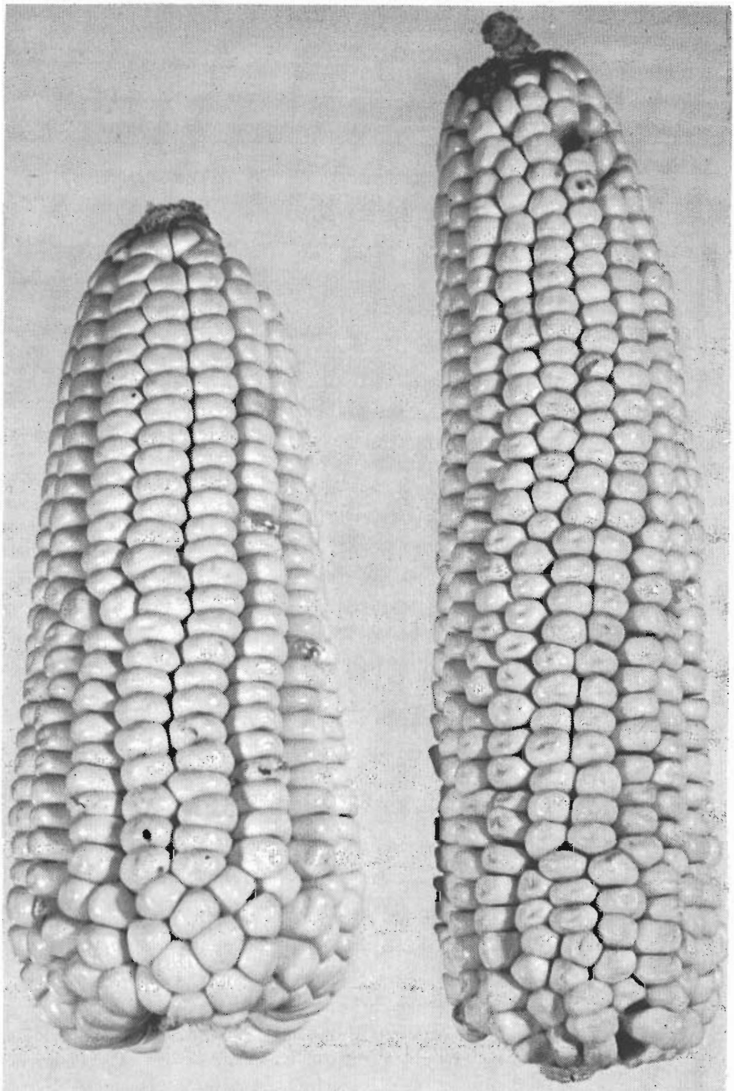


FIG. 225. Ajaleado ears, resemble the race Cholito from Bolivia, the Caingang floury dents of Brazil and some collections of Chuncho. (see Fig. 208).

SAN GERONIMO

Short plant, relatively early, with few leaves, 9 to 11, short and narrow; sun red plant color; ear position very low (Fig. 226). Tassel intermediate in size, sparsely branched. Ears globular, hand grenade-shaped with large floury, white, round, irregularly arranged kernels (Fig. 227).

Populations of San Geronimo are often found with variable ear types, which show a similarity to Cuzco, to Huancavelicano, or to San Geronimo-Huancavelicano.

This race is found in the Mantaro valley between Jauja and Huncayo, at a mean elevation of 3,200 meters above sea level. Its center of distribution is the district of San Geronimo, near the city of Huancayo.

FIG. 226. Plants of San Geronimo, showing the extremely low position of the ear, and short plant stature.

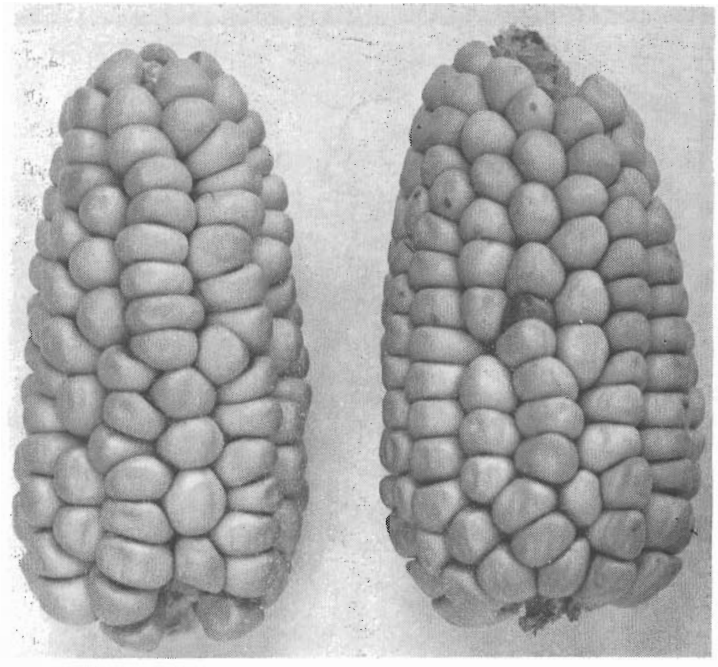


FIG. 227. San Geronimo, typical ears.

PERLILLA

Plants. Tall, average height at La Molina 2.32 m.; very late, 162 days to mid-silk when grown at the Mantaro Experiment Station (3,200 m. above sea level); number of leaves medium; length and width of leaves large, leaf area intermediate, 5,000 sq. cm.; venation index high; stalk thick, without tillers; development of prop roots slight to intermediate, ear position medium-high; plant color sun red, pubescence slight with hairs of medium coarseness, slightly susceptible to both rust and Helminthosporium.

Tassels. Peduncle very long, tassel large, well branched.

Ears, External Characters (Fig. 228). Short to medium in length, cylindrical, intermediate in diameter, 41.7 mm.; irregularly arranged kernels; shank long, thin with intermediate number of nodes (husks); kernels small in all dimensions, round, yellowish, endosperm yellow, flinty, hard; of five ears examined, three were colorless pericarp-red cob (AP^{wr}), and two were colorless pericarp-white cob.

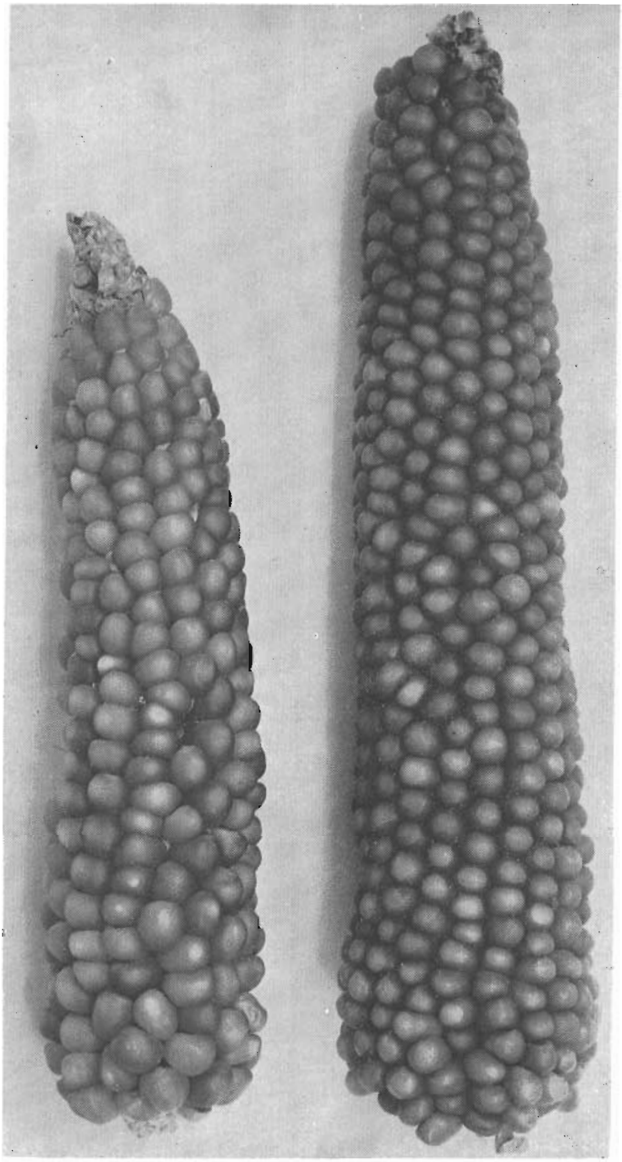


Fig. 228. Perlilla, characteristic ears.

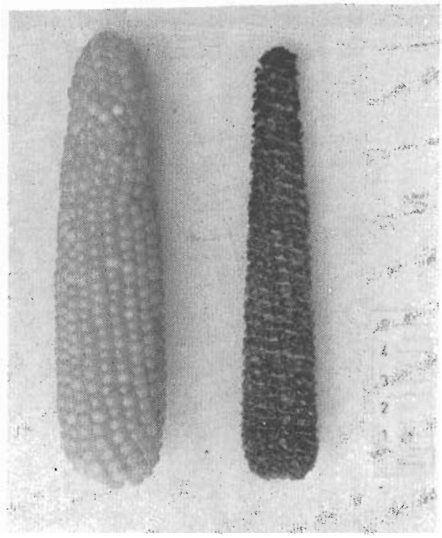


FIG. 229. Ear of Perlilla (greatly reduced) from the Department of Huanuco, matching an archaeological cob from a cave near Lauricocha, Huanuco (courtesy, Ing. Augusto Cardich).

Distribution. One single collection has been classified as typical, while several exhibit the characters of the extreme type to a lesser extent. The distribution of this race has been found limited to the lowlands of Huanuco. It is possible, however, that the central distribution of Perlilla may be eventually found in hitherto uncollected areas in the eastern part of the Departments of Huanuco, Pasco, and Junin, and in the Apurimac valley region. A collection intermediate between Confite Morocho and Perlilla, particularly having the height of plant of the latter race and resembling in ear characters the description given for the Colombian race Pira (Roberts *et al*, 1957), was procured in the Mantaro Quebrada, and probably represents a small peripherally migrant population of Perlilla.

Origin and Relationships. Nothing definite can be said about Perlilla at this time. If it proves to be a distinct race, it may well represent the missing link in the distribution of the round-seeded tropical popcorn races in the east Andean central lowlands. Pororo has been described as a member of this group of

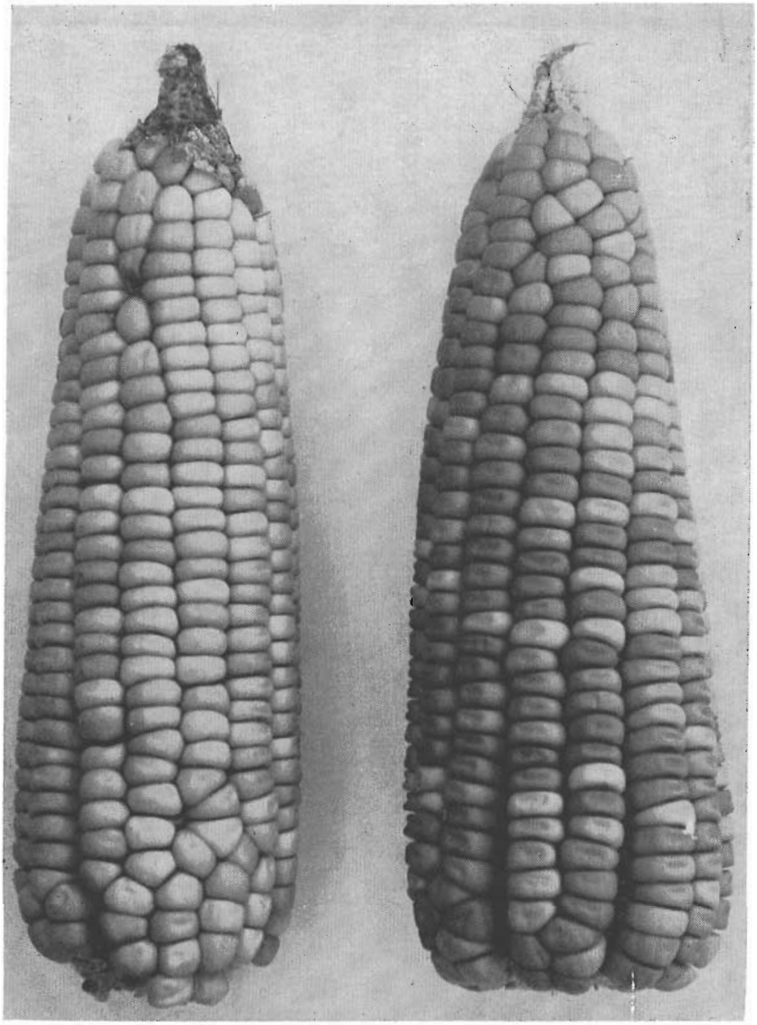


FIG. 230. Tumbesino, typical ears.

races in Bolivia (Ramirez *et al,* 1960). Pira and Pira Naranja from Colombia (Roberts *et al,* 1957) certainly seem to belong to it, as does the Avati-Pichinga-Ihu group of the Guarani area, described by Brieger *et al,* (1958) and perhaps Curagua of Chile is also a member of it.

Archaelogical corn cobs of still undertermined age, from caves near Lauricocha, Huanuco, were kindly furnished for study by Ing. Augusto Cardich. An ear was easily found in a collection of Perlilla, which matched perfectly these cobs (Fig. 229). This fact could provide evidence for the distinctiveness and certainly the antiquity of Perlilla.

TUMBESINO

This race is characterized by tall plants, medium ears with about 14 rows of medium white or yellow endosperm, floury or flinty kernels, usually showing several bronze or brown endosperm colors (Fig. 230). The ears are intermediate in type between Mochero grown in the valleys of the coast, south of Tembes, and the flinty types of the coast of Ecuador, which are apparently related to Chococeño.

Tumbes, where this race is prevalent, has a truly tropical rainy climate, quite different from the valleys south of Piura, on account of the distance of the cold Humboldt Current from the coast at latitudes immediately south of this province.

COLORADO

An incipient race which we are designating by the name of Colorado is present today in many of the valleys of the North Coast. After the race Arizona was introduced there, it hybridized with Alazan, which had been grown in the area for centuries. Selection was started by farmers to recombine the desirable ear characters and higher yield potential of Arizona with the red pericarp character, starchiness of kernels, and drought tolerance of Alazan. Most of the populations of Colorado are still segregating ear types ranging between the extreme parental types (Fig. 231), but some seem to have been fixed. An example of the latter is a selection which was extensively grown a few years ago at Hacienda Limoncarro, Jequetepeque valley.

CHANCAYANO AMARILLO

The plants of Chancayano Amarillo are very tall, with wide stalks, very large leaf area, and dilute sun red to green color.

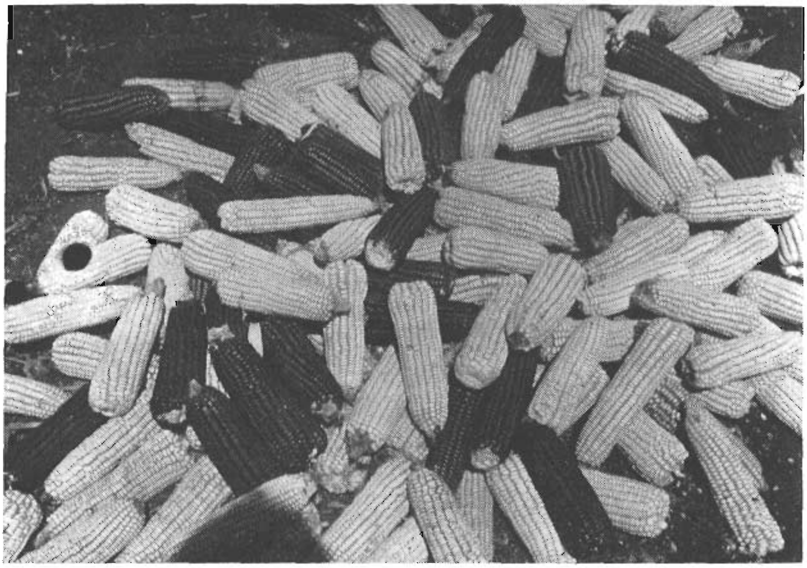


FIG. 231. Segregating ears in a hybrid population of Colorado and Arizona. The ears of Colorado, appear to have a tendency towards a larger row number

The ears are long, with 14 to 16 rows of medium, thick, semident kernels with yellow endosperm color.

This race is found in the Central Coast valleys, particularly in the Chancay, Huaura, and Rimac-Chillon, a distribution similar to that of the race Perla, with which it is extensively mixed in farmers' fields. There is a complete gradation in many collections of Perla to the Chancayano Amarillo racial ear type, which can be distinguished from the former only by its starchier, larger, semident kernels and the absence of orange pericarp color (Fig. 232).

Chancayano Amarillo was recognized as a distinct race from Perla late in these studies, and only after data of its breeding behavior showed it to have a different genetic structure (for grain yield component genes) in its populations than that of Perla. These two races are closely related. It seems evident the Chancayano Amarillo is a relatively modern race emerging from the hybridization of Chancayano and Perla. Tschudi's (1847) maize named Chancayano Amarillo appears from his description to fit better the race Perla, than that of present day Chancayano Amarillo.

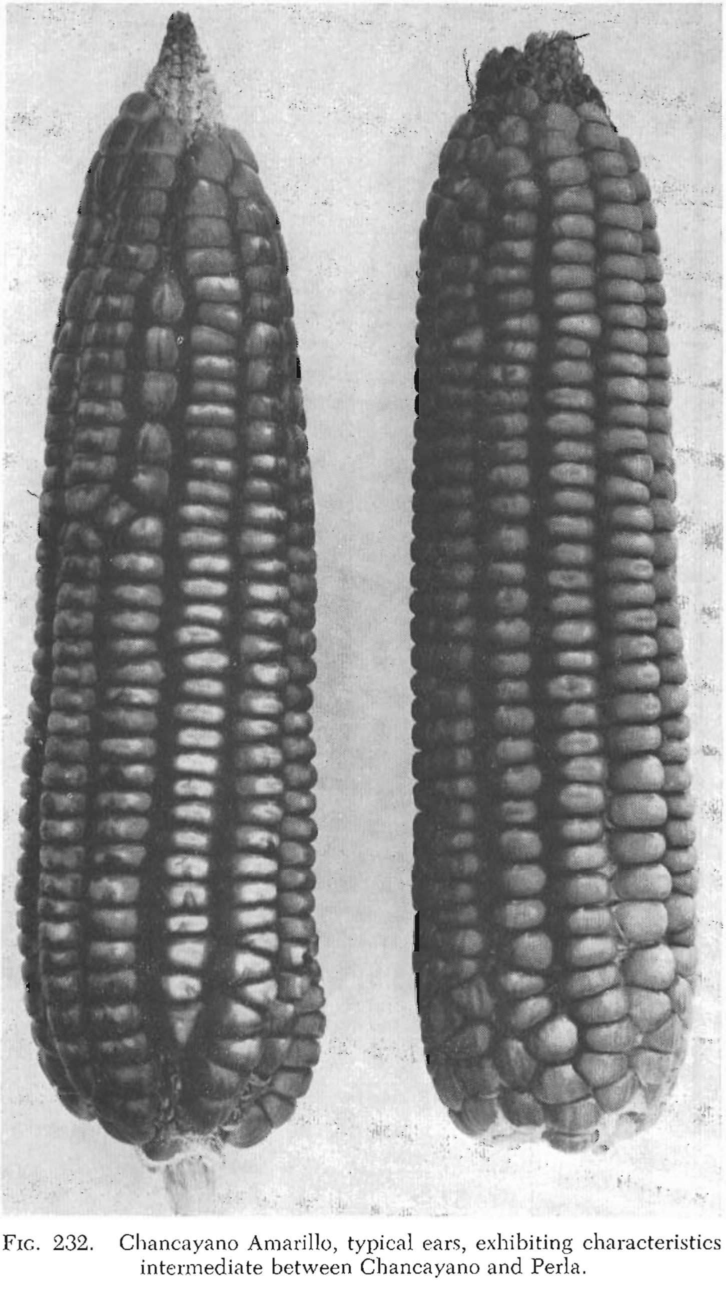


FIG. 232. Chancayano Amarillo, typical ears, exhibiting characteristics intermediate between Chancayano and Perla.

CONCLUSIONS

Maize in Peru exhibits more variation than in the other countries of this hemisphere where it has been studied. This variability is demonstrated in the range of adaptation to a vast array of ecological conditions, and in morphological, cytological and genetic characteristics.

Maize, the most important staple food in Peru since prehistoric times, has been subjected to selection for specialized uses as human food. Although quite varied in nature, this had led in many races to the development of large, floury kernels. Peru is unquestionably the present center of diversity of floury maize.

Except for a few rather late introductions, all the races of maize in Peru appear to have originated in the Andes of Peru or Bolivia from a small number of precursor races. Two of these precursors were popcorns, Confite Chavinense, a fasciated-spherical eared race, and Proto-Confite Morocho which was characterized by its slender ear with 8 to 10 rows of imbricated kernels. A third precursor, Proto-Kculli, could have been an independently domesticated popcorn or a derivative of Proto-Confite Morocho; it is the forerunner of some of the highly-anthocyanin-pigmented races of the Andes. Archaeological and living popcorn races in Peru and neighboring countries which can be traced back in ancestry to these precursors are: Confite Puntiagudo, Pisankalla, Confite Iqueño, Confite Puneño, Enano, Proto-Pagaladroga, Pollo, Avati-Pichinga, and Polulo.

There appears to be strong evidence to indicate that a domestication of maize took place in the Central Andes independent of a similar process which occurred in Middle America. Although the areas where wild corn was first placed under cultivation in the Andes cannot be definitely ascertained from the information now available, we may, nevertheless, infer from the distribution of archaeological maize and of living Anciently Derived races, that such areas must have been at the intermediate altitudes, perhaps from 2,000 to 2,800 meters above sea level.

Maize seems to have been introduced from the Peruvian highlands to the coast where it was added, together with peanuts, to the previously existing cropping pattern of gourd, squashes, cotton and beans. The consistent appearance of both corn and peanuts at several early archaeological sites may be an indication

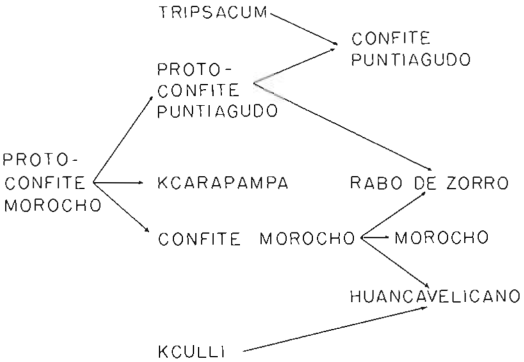


FIG. 233. Races directly derived from Proto-Confite Morocho.

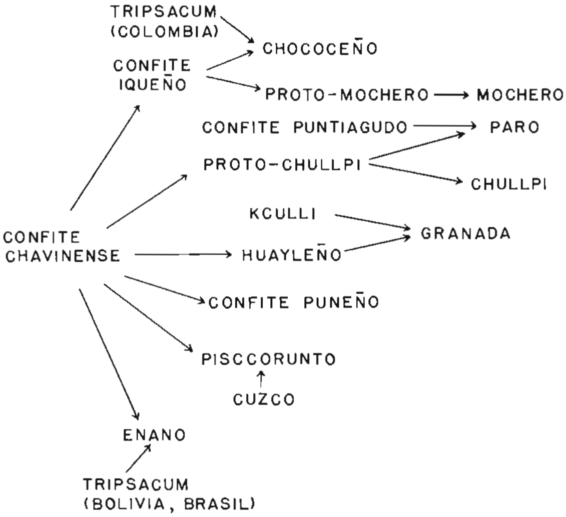


FIG. 234. Primarily derived races from Confite Chavinense.

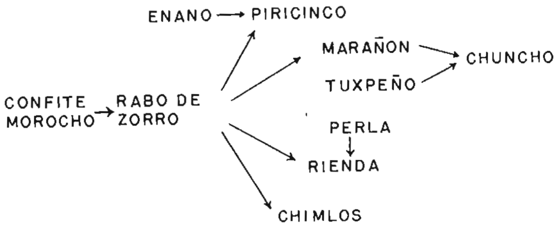


FIG. 235. Races derived from Rabo de Zorro.

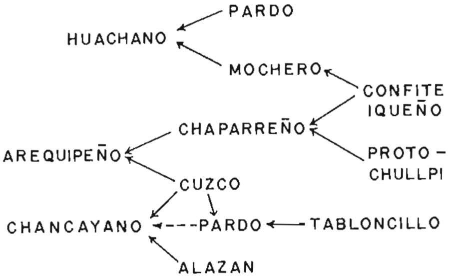


FIG. 236. Postulated Origins of Coastal floury races.

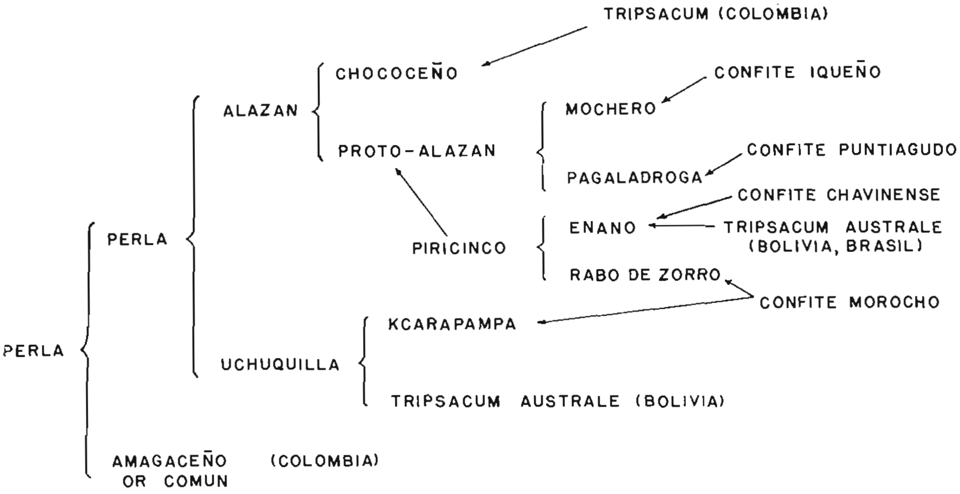


Fig. 237. Proposed Pedigree of Perla.

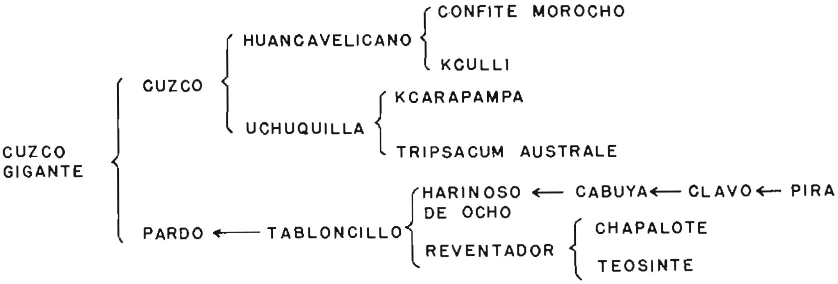


Fig. 238. Proposed Pedigree of Cuzco Gigante.

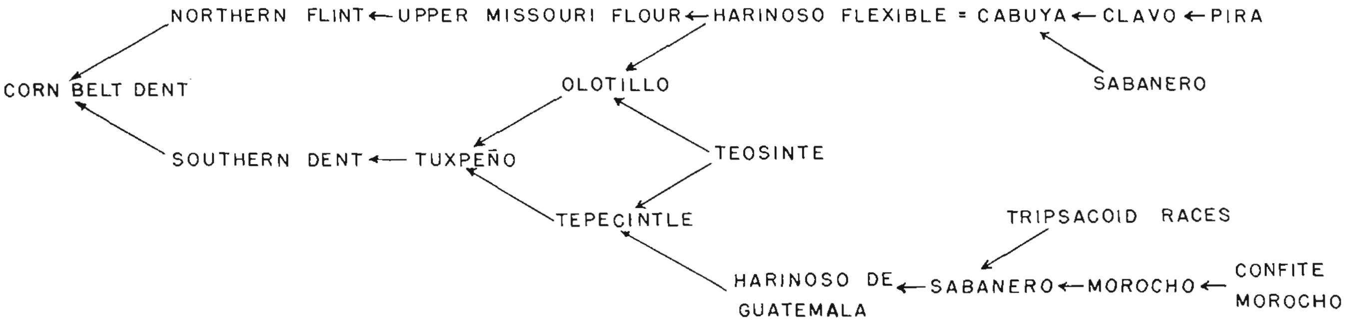


Fig. 239. Proposed Pedigree of Corn Belt Dent.

of the introduction to the coast of an agricultural complex based on these two crops which originated in the inter-Andean valleys or on the eastern Andean slopes.

As corn cultivation extended in area, small isolated populations or ecological races were developed, acquiring in the course of time enough genetic diversity to become individual races. Some of these derived populations hybridized among themselves, or with the popcorn precursors, to give rise to an additional number of races. These have been designated as Anciently Derived and they number nineteen. Thirteen of these developed in the middle to high altitudes of the Andes, four on the coast, and two on the eastern Andean slopes at medium to low elevations.

In the periphery of the central Andean region, probably in the lowlands of Bolivia, cultivated maize and *Tripsacum australe* may have come in contact and introgressive hybridization between the two species may have occurred. At least three tripsacoid maize races, Confite Puntiagudo, Enano and Uchuquilla were thus derived, possibly 2,000 to 3,000 years ago (Table 7). These in turn introduced blocks of Tripsacum genes, in varying amounts, into at least seven of the Anciently Derived races. Only two of these races, however, both of low altitudes, received any appreciable amount of Tripsacum germplasm.

At least twenty four races of maize were in existence in Peru by 1500 A.D. Most of them can be directly demonstrated by archaeological material. Further hybridization among these races and with a few introduced races yielded from ten to twenty so-called Lately Derived and Incipient new races. Most of the races in these later groups are grown at lower altitudes than the earlier races.

Only one of the introduced races, Pardo, may be considered as a pre-Columbian or early post-Columbian introduction from Mexico. The other introductions are not over 100 years old.

The available evidence suggests that the influence of Middle American maize on Andean maize has been very limited until quite recently. The movement of maize races appears to have been predominantly centrifugal to the central Andes. In spite of this, there has been a decidedly strong influence on some of the maize of the coast by maize from Colombia, particularly of the race Chococeño (itself derived from a Peruvian popcorn race, Confite Iqueño, introgressed by Tripsacum); and from maize races of Bolivia on both highland and lowland maize of Peru.

The modern exceedingly productive races of the coast and Sierra are complex hybrids, as is shown by the pedigrees of Perla and Cuzco (Figs. 237 and 238, respectively) where highly heterotic genetic components—traceable in origin to different popcorn races—have been assembled. Furthermore, *Tripsacum* x *Zea Mays* and *Tripsacum* x *Tripsacum* heterotic components may be involved in conditioning the high yield of such races. These races are true counterparts of the highly evolved Corn Belt dent maize of the United States of America, in the sense that their high level of agronomic performance may be explained by the aggregation of wide genetic diversity into their racial germplasm, and that they represent the ultimate evolutionary products of several converging maize and *Tripsacum* (or teosinte) phylogenetic lines of descent.

The evolution of maize in Peru, as well as in other areas, appears to have proceeded as a continuing process of the accumulation of genetic diversity and residual heterosis, resulting from interracial hybridization and subsequent selection. Considerable genetic variability is still persent in Peruvian maize, and in that of other areas, awaiting the judicious employment by breeders in directing the evolution of this cereal towards the attainment of still greater productivity.

SUMMARY

Nearly 1600 maize collections, assembled since 1952 from all parts of Peru, were grown at eleven locations and studied both in the field and laboratory, with respect to their geographical distribution, and their morphological, cytological, genetic, and physiological characteristics, with the objective of classifying them into races, and of further establishing their probable origins and affinities.

A survey of the available maize plant, ear, and ceramic archaeological material complemented the study of the living maize and helped in outlining the pathways of evolution of this cereal in the central Andean region.

The following results and conclusions have been derived from these studies:

1. Twenty four pre-Columbian races of maize from Peru and

Bolivia are recognized and described. These have been classified according to geographical distribution and time of appearance.

2. All the pre-Columbian maize in Peru can be traced back in origin to two or possibly three ancient popcorn races, Confite Chavinense, Proto-Confite Morocho and Proto-Kculli. These probably occurred originally in the middle altitudes of the Andes, where they were domesticated from one or more wild maize races. These ancestral popcorns are represented today by relatively slightly altered primitive races.

3. The factors responsible for the evolution of maize in Peru have been chronologically: (a) initial breakdown of the continuity of the distribution of maize due to physiographic factors with the resultant formation of ecologically isolated races thus increasing the genetic variability of the species; (b) natural hybridization among races, followed by artificial selection for specific utilization; (c) subsequent direct introgression of Tripsacum where the ranges of the two genera overlapped, in the periphery of the central Andean region; (d) limited Tripsacum gene flow to the center of distribution of Andean maize; (e) maize introductions in rather late periods, followed by hybridization and the fixation of new races.

4. The highly evolved modern races of maize in Peru are complex hybrids resulting probably from the systematic compounding of many lines of descent, leading back to several ancestral popcorn races, and to *Tripsacum* species, mainly to races of *T. australe.* Complex heterotic interactions, in racial hybrids, may result from genes contributed by the parental maize races, and from blocks of genes originally present in Tripsacum.

5. There is an extraordinary large variability of maize in the Peruvian area in morphological, genetical, cytological and ecological characteristics.

6. Forty nine modern races of maize are recognized and described. These races are classified as (a) Primitive, when they have characteristics directly derived from a simple popcorn ancestor; (b) Anciently Derived, when they originated by isolation, hybridization and selection in pre-Columbian times; (c) Lately Derived, when they can be traced back to Anciently Derived parents; and are largely post-Columbian; (d) Introduced; (e) Incipient; (f) Imperfectly Defined.

7. The Primitive races number five, Confite Morocho, Confite

Puntiagudo, Confite Puneño, Kculli and Enano. Four of these are still grown in the highlands. There are nineteen Anciently Derived races, thirteen of which grow at high altitudes. The Lately Derived races, as well as the Introduced and Incipient races, in general, have higher yields. Not all the maize in Peru could be classified as distinct races. A few groups are provisionally designated as Imperfectly Defined races, pending further studies.

8. The Central Andean maize domestication center has undoubtedly made a much greater contribution of germplasm to the Middle American maize domestication center than it, in turn, received from the latter. Only in later times, and particularly within the last century, has Middle American maize infiltrated into Peru to any appreciable extent.

REFERENCES

ACOSTA, JOSE, 1590. Historia natural y moral de las Indias. Sevilla. Fondo de Cultura Economica. Mexico (1940).

AMES, O., 1939. Economic Annuals and Human Cultures. Botanical Museum of Harvard University. Cambridge.

ANDERSON, EDGAR, 1944. Homologies of the ear and tassel in *Zea Mays*. Ann. Mo. Bot. Gard. 31:325-344.

ANDERSON, E., and BLANCHARD, F. D., 1942. Prehistoric maize from Cañon del Muerto. Amer. Jour. Bot. 29:832-835.

ANDERSON, E., and ERICKSON, RALPH O., 1941. Antithetical dominance in North American maize. Proc. Nat. Acad. Sci. 27:436-440.

ARRIAGA, PABLO JOSE DE, 1621. Extirpacion de la idolatria de los indios del Peru y de los medios para conversion de ellos. Lima. Buenos Aires (1910).

AVILA, FRANCISCO DE, 1608. Dämonen und Zauber im Inkareich. (German translation by Hermann Trimborn). Leipzig. Text in Quichua and German (1939).

BARGHOORN, E. S., WOLFE, M. K., and CLISBY, K. H., 1954. Fossil maize from the valley of Mexico. Bot. Mus. Leafl. Harvard University. 16:229-240.

BAUDIN, L., 1928. L'Empire Socialiste des Incas. Paris.

BENNETT, WENDELL C., 1948. The Peruvian co-tradition. A reappraisal of Peruvian archaeology. pp. 1-7. Menasha, Wis. (Memoirs Soc. for Amer. archaeology. No. 4).

BENNETT, W. C., and BIRD, J. C., 1949. Andean culture history. Amer. Mus. of Natural History. Handbook Series No. 15, pp. 319. New York.

BETANZOS, JUAN DE, 1880. Suma y narracion de los Incas. Ed. Marcos Jimenez de la Espada. Biblioteca Hispano-Ultramarina. Vol. 5. Madrid.

BIRD, JUNIUS, 1938. Antiquity and migrations of the early inhabitants of Patagonia. Geogr. Rev. 28:250-275.

——— 1948. Preceramic cultures in Chicama and Viru. *In* Bennett, W. C. Reappraisal of Peruvian Archaeology. pp. 21-28. Menasha. Wis.

BIRKET-SMITH, K., 1943. The origin of maize cultivation. Kgl. Danske Videnskabernes Selskab. Hist. Filol. Meddel. 293: 1-49.

BOSEMARK, N. O., 1957. On accessory chromosomes in *Festuca pratensis*. V. Influence of accessory chromosomes on fertility and vegetative development. Hereditas (Lund) 43:211-235.

BOWMAN, ISAIAH, 1916. The Andes of Southern Peru. The American Geographical Society. New York.

BRIEGER, F. G., 1937. Genetic control of gametophyte development in maize. I. A gametophyte character in chromosome five. Jour. Genet. 34:57-80.

BRIEGER, F. G., GURGEL, J. T. A., PATERNIANI, E., BLUMENSCHEIN, A., and ALLEONI, M. R., 1958. Races of maize in Brazil and other eastern South American countries. Natl. Acad. Sci.-Natl. Res. Council Publ. No. 593.

BRINK, R. A., 1958. Paramutation at the *R* locus in maize. Cold Spring Harbor Symp. Quant. Biol. 23:379-391.

BRINK, R. A., and NILAN, R. A., 1952. The relation between light variegated and medium variegated pericarp in maize. Genetics 37:519-544.

BROWN, R. W., 1934. The supposed fossil ear of maize from Cuzco, Peru. Jour. Wash. Acad. Sci. 24:293-296.

BUSHNELL, G. H., 1957. Peru. Frederick A. Praeger. New York.

CALANCHA, FR. ANTONIO JOSE DE, 1638. Cronica moralizadora del Orden de San Agustin. Lima, 1653.

CARDICH, AUGUSTO, 1958. Los yacimientos de Lauricocha. Nuevas interpretaciones de la Prehistoria Peruana. Centro Argentino de Estudios Prehistoricos. Studia Praehistorica, 1. Buenos Aires.

——— 1960. Yacimientos arquelogicos de Lauricocha son los mas antiguos de nuestro pais. "El Comercio," Lima, March 22, 1960.

CHEVALIER, A., 1929. L'origine botanique et l'amélioration des Arachides cultiveés. Rev. Bot. Appl. Agric. Colon, 9:97-102, 190-197.

CIEZA DE LEON, PEDRO, 1533. Cronica general del Peru. Primera parte. Sevilla. Segunda Parte de la Cronica del Peru que trata del Señorio de los Incas Yupanquis y de sus grandes hechos y gobernacion. Madrid (1880).

CLAUSEN, JENS, and HIESEY, W. M., 1958. Experimental studies on the nature of species. IV. Genetic structure of ecological races. Carnegie Inst. of Washington. Washington, D. C.

COBO, BERNABE, 1653. Historia del Nuevo Mundo. Publicada por primera vez con notas y otras ilustraciones de M. Jimenez de la Espada. 4 Vol. Sevilla (1890).

COLLINS, G. N., 1919. A fossil ear of maize. Jour. Heredity 10:170-172.

——— 1923. Notes on the agricultural history of maize. Ann. Report. Amer. Historical Soc. for year 1919. I:411-429.

COSTANTIN, V., and BOIS, D., 1910. Sur les grains et tubercules des tombeaux Peruviens de la periode Incasique. Revue Generale de Botanique. 22:242-265.

COOK, O. F., 1925. Peru as a center of domestication. Jour. Heredity. 16:33-46. 95-110.

CUTLER, H. C., 1946. Races of maize in South America. Bot. Mus. Leafl. Harvard University. 12:257-291.

CUTLER, H. C., and ANDERSON, E., 1941. A preliminary survey of the genus Tripsacum. Ann. Mo. Bot. Gard. 28:249-269.

CUTLER, H. C., and CUTLER, M. C., 1948. Studies on the structure of the maize plant. Ann. Mo. Bot. Gard. 35:301-316.

DA CUNHA, BRITO, A., and DOBZHANSKY, T., 1954. A further study of chromosomal polymorphism in *Drosophila Willistoni* in its relation to the environment. Evolution. 8:119-134.

DARLINGTON, C. D., 1956a. Natural populations and the breakdown of classical genetics. Proc. R. Soc. Ser. B. Biol. Sc. Lond. 145:350-364.

——— 1956b. Chromosome Botany. Allen and Unwin. London.

DARWIN, C .R., 1851. Geological observations on coral reefs, volcanic islands and on South America. Pt. II, pp. 47-49. London.

DE CANDOLLE, ALPHONSE, 1886. Origin of cultivated plants. Hafner Publ. Co. New York (1959).

EMERSON, R. A., 1925. A possible case of selective fertilization in maize hybrids. Anat. Rec. 29:136.

EMERSON, R. A., BEADLE, G. W., and FRASER, A. C., 1936. A summary of linkage studies in maize. Cornell University Agr. Expt. Sta. Memoir 180:1-83.

EMMERLING, M. H., 1956. Evidence of increased mutation frequency in presence of homozygous knob-10. Maize Genetics Coop. News Letter 30:65-67.

ENGEL, FREDERIC, 1955. Les amas de coquillages de la cote Peruvienne (Ancon-Rio Ica). Jour. de la Societe des Americanistes 44:39-47.

—— 1960. Declarations of Dr. Engel to "El Comercio," Lima, March 1960.

FALCONER, D. S., 1960. Introduction to Quantitative Genetics. The Ronald Press Co. New York.

FRÖST, S., 1958. Studies of the genetical effects of accessory chromosomes in *Centaurea scabiosa.* Hereditas (Lund). 44:75-111.

GALINAT, W .C., 1960. The mutagenic effects of homozygous and heterozygous teosinte chromosomes in an isogenic stock. Maize Genetics Coop. News Letter 34:37.

GALINAT, W. C., MANGELSDORF, P. C., and PIERSON, L., 1956. Estimates of teosinte introgression in archaeological maize. Bot. Mus. Leafl. Harvard University. 17:101-124.

GALINAT, W. C., and RUPPE, REYNOLD J., 1961. Further archaeological evidence on the effects of teosinte introgression in the evolution of modern maize. Bot. Mus. Leafl. Harvard University 19:163-181.

GARCILASO DE LA VEGA, INCA, 1609-1617. Comentarios Reales. Primera parte, Lisboa, 1609. Segunda parte, Cordova, 1617.

GRANER, E. A., and ADDISON, G., 1944. Meiose em *Tripsacum australe* Cutler e Anderson (*T. dactyloides* subsp. *hispidum* Hitchcock). Anais da Escola Superior de Agricultura "Luiz de Queiroz." (Separata No. 9) 1:213-224.

GREGORY, WALTON C., 1956. Induction of useful mutations in the peanut. *In* Genetics in Plant Breeding. Brookhaven Symp. in Biol. No. 9:177-190.

GROBMAN, ALEXANDER, 1953. Medida practica de superficies foliares en maize. Agronomia. Lima. 18:3-11.

—— 1957. Geographic distribution of pericarp and cob color gene frequencies of Peruvian highland corn. Maize Genetics Coop. News Letter 31:56-57.

—— 1958a. Test for sugary endosperm gene in Chullpi, Andean sweet corn. Maize Genetics Coop. News Letter 32:26.

—— 1958b. A leaf growth pattern index for differentiating strains of maize. Maize Genetics Coop. News Letter. 32:27-28.

—— 1959. New sources of cytoplasmic pollen sterility. Maize Genetics Coop. News Letter. 33:27.

GROBMAN, A., and SWANSON, A. F., 1955. Amylose in starch of Peruvian Andean corn. Maize Genetics Coop. News Letter. 29:21-22.

GUAMAN POMA DE AYALA, FELIPE, 1613. Nueva cronica y buen gobierno. ms. a principios del siglo XVII. Facsimilar Edit. Paris (1936).

HALDANE, J. B. S., 1954. The Biochemistry of Genetics. Allen and Unwin Ltd. London.

HARLAN, J. R., 1951. Anatomy of gene centers. Amer. Natur. 85:97-103.

—— 1956. Distribution and utilization of natural variability in cultivated plants. *In* Genetics in Plant Breeding. Brookhaven Symp. in Biol. No. 9:191-208.

HARMS, HERMAN VON, 1922. Ubersicht der bischer in altperuanischen Grabern gefundenen Pflanzenreste. Festschrift Eduard Seler, 157-186. Stuttgart.

HARSHBERGER, J. W., 1893. Maize, a botanical and economic study. Contr. Bot. Lab. Univ. of Pa. 1:75-202.

HATHEWAY, W. H., 1957. Races of maize in Cuba. Natl. Acad. Sci.—Natl. Res. Council Publ. No. 453.

HERRERA, FORTUNATO L., 1941. Sinopsis de la flora del Cuzco. Vol. I. Parte sistematica. Lima.

HORKHEIMER, HANS, 1958. La alimentacion en el Peru Prehispanico y su interdependencia con la agricultura. UNESCO. Programa de Estudios de la Zona Arida Peruana. (Mimeographed). pp. 106. Lima.

KEMPTON, J. H., 1937. Maize our heritage from the Indian. Smithsonian Inst. Rept. 1937:385-408.

KEMPTON, J. H., and POPENOE, W., 1937. Teosinte in Guatemala. Carnegie Inst. Wash. Publ. 483:199-218.

KNOCH, K., 1930. Klimakunde von Sudamerika. *In* Koppen, W. and Geiger, R. Handbuch der Klimatologie. Vol. 2, Part G. Berlin (in Weberbauer A. 1945).

KNOWLTON, F. H., 1919. Description of a supposed new fossil species of maize from Peru. Jour. Wash. Acad. Sci. 9:134-136.

KOHNICKE, F., and WERNER, H., 1885. Handbuch des Getreidebaues I. Die Asten und Varietaten des Getreides. Berlin.

KRAPOVICKAS, ANTONIO, and RIGONI, V. A., 1957. Nuevas especies de *Arachis* vinculadas al problema del origen del mani. Darwiniana 11:431-455.

KROEBER, A. L., 1949. A cross cultural survey of South American Indian tribes. *In* Handbook of South American Indians. *Ed.* J. H. Steward. Bulletin 143, Bureau of American Ethnology. Volume 5:411-492.

KULESHOV, N .N., 1929. The geographical distribution of the varietal diversity of maize in the world. Bull. Appl. Bot. Genet. Plant Breeding 20:506-510.

KUWADA, Y., 1911. Meiosis in the pollen mother cell of *Zea Mays*. Botan. Mag. (Tokyo) 25:163-181.

LARCO HOYLE, RAFAEL, 1946. A culture sequence for the North Coast of Peru. *In* Handbook of South American Indians. *Ed.* J. H. Steward. Bulletin 143, Bureau of American Ethnology. Volume 2:149-175.

LENZ, LEE WAYNE, 1948. Comparative histology of the female inflorescence of *Zea Mays* L. Ann. Mo. Bot. Gard. 35:353-376.

LERNER, I. M., 1950. Population genetics and animal improvement. University Press., Cambridge.

——— 1954. Genetic Homeostasis. John Wiley and Sons. New York.

LEVENE, HOWARD, 1953. Genetic equilibrium when more than one ecological niche is available. Amer. Nat. 87:331-333.

LEWIS, H., 1953. Quantitative variation in wild genotypes of *Clarkia*. I. U. B. S. Symposium on Genetics Population Structure, Pavia 1953, pp. 114-125.

LONGLEY, A. E., 1927. Supernumerary chromosomes in *Zea Mays*. Jour. Agr. Res. 35:769-784.

——— 1937. Morphological characters of teosinte chromosomes. Jour. Agr. Res. 54:835-862.

——— 1938. Chromosomes of maize from North American Indians. Jour. Agr. Res. 56:177-196.

——— 1939. Knob positions on corn chromosomes. Jour. Agr. Res. 59:475-490.

LOPEZ DE JEREZ, FRANCISCO, 1534. Verdadera relacion de la Conquista del Peru. Sevilla.

LOPEZ DE VELASCO, JUAN, 1894. Geografia y description universal de las Indias, recopilada por el cosmografo-cronista desde el año 1571 al de 1574. Madrid.

MACBRIDE, J. FRANCIS, 1936. Flora of Peru. Part I. Field Museum of Natural History. Publication 351. Chicago.

MACNEISH, R. S., 1955. Ancient maize in Mexico. Archaeology. 8:108-115.

——— 1958. Preliminary archaeological investigations in the Sierra de Tamaulipas. Mexico. Trans. Amer. Philos. Soc. 48, pt. 6:1-210.

MANGELSDORF, A. J., 1952. Gene interactions in Heterosis. *In* Heterosis. *Ed.* J. W. Gowen. pp. 320-329. Iowa State College Press. Ames.

MANGELSDORF, PAUL C., 1926. The genetics and morphology of some endorsperm characters in maize. Conn. Agr. Expt. Sta. Bul. 279:509-614.

——— 1942. Identification of vegetal remains from Nazca and Paracas (Unpublished report).

——— 1948. The role of Pod Corn in the origin and evolution of maize. Ann. Mo. Bot. Gard. 35:377-407.

——— 1952. Hybridization in the Evolution of Maize. *In* Heterosis. *Ed.* J. W. Gowen. pp. 175-198. Iowa State College Press. Ames.

——— 1953. Geographical variation in gene frequencies. Maize Genet. Coop. News Letter 27:22-24.

—————— 1958a. The mutagenic effects of hybridizing maize and teosinte. Cold Spring Harbor. Symp. Quant. Biol. 23:409-421.

—————— 1958b. Reconstructing the ancestor of corn. Proc. Amer. Philos. Soc. 102:454-463.

MANGELSDORF, P. C., and CAMERON, J. W., 1942. Western Guatemala, a secondary center of origin of cultivated maize varieties. Bot. Mus. Leafl. Harvard University. 10:217-252.

MANGELSDORF, P. C., and GALINAT, W. C., 1960. The gene for tunicate a compound locus? Maize Genet. Coop. News Letter 34:36.

MANGELSDORF, P. C., and JONES, D. F., 1926. The expression of Mendelian factors in the gametophyte of maize. Genetics 11:423-455.

MANGELSDORF, P. C., MACNEISH, R. S., and GALINAT, W. C., 1956. Archaeological evidence on the diffusion and evolution of maize in Northeastern Mexico. Bot. Mus. Leafl. Harvard University 17:125-150.

MANGELSDORF, P. C., and REEVES, R. G., 1939. The origin of Indian corn and its relatives. Texas Agr. Expt. Sta. Bul., 574. 1-315.

——————, 1959. The origin of corn. III. Modern races, the product of teosinte introgression. Bot. Mus. Leafl. Harvard University 18:389-411.

——————, 1959. The origin of corn. IV. Place and time of origin. Bot. Mus. Leafl. Harvard University 18:413-427.

MANGELSDORF, P. C., and SMITH, C. E., 1949. New archaeological evidence on evolution in maize. Bot. Mus. Leafl. Harvard University 13:213-247.

MATHER, K., 1943. Polygenic inheritance and natural selection. Biol. Reviews 18:32-64.

MATHER, K., and WIGAN, L. G., 1942. The selection of invisible mutations. Roy. Soc. Proc. *B*, 131:50-64.

MAYER-OAKES, W. J., and BELL, R. E., 1960. Early man site found in highland Ecuador. Science 131:1805-1806.

MAYR, E., 1942. Systematics and the origin of species. Columbia University Press. New York.

MCCLINTOCK, B., 1929. Chromosome morphology in *Zea Mays*. Science 69:629.

——————, 1950. The origin and behavicr of mutable loci in maize. Proc. Natl. Acad. Sci. U .S. 36:344-355.

——————, 1951. Chromosome organization and genic expression. Cold Spring Harbor Symp. Quant. Biol. 16:13-47.

——————, 1956. Controlling elements and the gene. Cold Spring Harbor Symp. Quant. Biol. 21:197-216.

——————, 1959. Chromosome constitution of some South American races of maize. Carnegie Inst. Wash. Yearbook 58:454-456.

MEANS, PHILIP AINSWORTH, 1931. Ancient civilizations of the Andes. C. Scribners Sons, 1931. New York. London.

MEJIA XESSPE, TORIBIO, 1931. Kausay. Alimentacion de los Indios. *In* Wirakocha 1 (1):9-24. Lima.

MESA BERNAL, D., 1955. De donde es originario el maiz? III. Colombia considerado como centro de origen. Agricultura Tropical 11 (9):753-758.

MOLINA, CRISTOBAL DE, 1533. Las cronicas de los Molinas. Destruccion del Peru. Fabulas y ritos de los Incas. 1574. Imprenta D. Miranda, Lima. 1943.

MOLL, R. H., ROBINSON, H. F., and COCKERHAM, C. CLARK, 1960. Genetic variability in an advanced generation of a cross of two open-pollinated varieties of corn. Agron. Jour. 52:171-173.

MONARDES, NICOLAS, 1569. Historia medicinal de las cosas que traen de nuestras Indias Occidentales que sirven de medicina. Sevilla.

MONTGOMERY, F. G., 1911. Correlation studies of corn. Nebr. Agr. Expt. Sta. 24th Annual Report.

MORENO, ULISES, 1960. Estudio del numero de cromosomas tipo B y de la frequencia y posicion de nudos cromosomicos en razas de maiz del Peru. Agronomia. (Lima) 27:39-51.

Morua, Martin de, 1590. Los origenes de los Inkas; cronica sobre el antiguo Peru, escrita en el año de 1590. (Estudio bio-bibliografico sobre el autor por Raul Porras Barrenechea). Los pequeños grandes libros de la Historia Americana. Ser. I, Vol. XI. Lima (1946).

Müntzing, Arne, 1958. A New Category of chromosomes. Proceedings of the X International Congress of Genetics. Vol. I, 453-467.

Nelson, Oliver E., Jr., 1952. Non-reciprocal cross-sterility in maize. Genetics 37:101-124.

Nicholson, G. Edward, 1958. A note on types of maize in Peru. 13 pp. Mimeographed.

——— 1960. Chicha maize types and chicha manufacture in Peru. Economic Bot. 14:290-299.

Nickerson, Norton H., 1953. Variation in cob morphology among certain archaeological and ethnological races of maize. Ann. Mo. Bot. Gard. 40: 79-111.

Oviedo, Gonzalo Fernandez de, 1535. Historia Natural y General de las Indias. Madrid (1851-1855). 4 Volumes.

Pareja-Paz Soldan, Jose, 1950. Geografia del Peru. Vol. I. Lima.

Peterson, P. A., 1960. The pale green mutable system in maize. Genetics 45: 115-133.

Pizarro, Hernando, 1533. Letter to the Royal Audience of Santo Domingo. *In* Reports on the Discovery of Peru. Hakluyt Soc. Pub. No. 47, pp. 11-127. London (1872).

Polo de Ondegardo, Juan, 1585. Los errores y supersticiones de los Indios. Lima.

Pulgar Vidal, Javier, 1946. Historia y Geografia del Peru. Vol. I. Las Ocha Regiones Naturales del Peru. Universidad Nacional Mayor de San Marcos, Ed. Lima.

Ramirez, R. E., Timothy, D. H., Diaz, B. Efrain, Grant, U. J., *in collaboration with* Nicholson, G. E., Anderson, E., and Brown, W. L., 1960. Races of maize in Bolivia. Natl. Acad. Sci.-Natl. Res. Council Publ. No. 747.

Randolph, L. F., 1941. Genetic characteristics of the B-chromosomes in maize. Genetics 26:608-631.

——— 1959. The origin of maize. Indian Jour. of Genetics and Plant Breeding. 19:1-12.

Reeves, R. G., 1950. The use of teosinte in the improvement of corn inbreds. Agron. Jour. 42:248-251.

Reiss ,W., and Stubel, A., 1880-1887. The Necropolis of Ancon in Peru. 3 Vol. New York, London, and Berlin.

Rhoades, M. M., 1933. The cytoplasmic inheritance of male sterility in *Zea Mays*. J. Genet. 27:71-93.

——— 1938. Effect of the *Dt* gene on the mutability of the a_1 allele in maize. Genetics 23:377-397.

——— 1955. The cytogenetics of maize. *In* Corn and Corn Improvement. Edited by G. F. Sprague, pp. 123-219. Academic Press. Inc. New York.

Roberts, L. M., Grant, U. J., Ramirez, E. R., Hatheway, W. H., Smith, D. L., *in collaboration with* Mangelsdorf, P. C., 1957. Races of maize in Colombia. Natl. Acad. Sci.—Natl. Res. Council Publ. No. 510.

Robinson, H. F., Comstock, R. E., and Harvey, P. H., 1949. Estimates of heritability and the degree of dominance in corn. Agron. Jour. 41:353-359.

Rochebrune, Alfonse Tremeau de, 1879. Recherches d'Etnographie botanique sur la flore des sepultures Peruviennes d'Ancon. Actes Societe Linneaus. Bordeaux 3:343-358.

Roman, H., 1947. Mitotic non-disjunction in the case of interchanges involving the B-type chromosomes in maize. Genetics 32:391-409.

Romero, Emilio, 1937. Historia Economica y Financiera del Peru. Vol. I. Antiguo Peru y Virreynató. Lima.

Rosbaco, Urbano F., 1951. Consideraciones sobre maices "amargos" con especial references a su cultivo en la provincia de Entre Rios. Idia No. 46:1-12.

ROWE, JOHN HOWLAND, 1945. Absolute chronology in the Andean area. Amer. Antiq. *10:265-284.*

RUSTISHAUSER, A., 1956. Genetics of fragment chromosomes in *Trillium grandiflorum.* Heredity 10:195-204.

SAUER, CARL O., 1950. Cultivated plants of South and Central America. In Handbook of South American Indians. *Ed.* J. H. Steward. Bulletin 143 Bureau of American Ethnology. Volume 6:487-543.

——— 1952. Agricultural origins and dispersals. The American Geographical Soc. New York.

SAX, KARL, 1931. Crossing over and mutation. Proc. Nat. Acad. Sci. 17:601-603.

SCHWARTZ, DREW, 1950. The analysis of a case of cross-sterility in maize. Proc. Nat. Acad. Sci. U. S. 36:719-724.

SEHGAL, S. M., 1961. A new method for estimating teosinte and Tripsacum introgression into maize. Maize Genet. Coop. News Letters 35.

SPINDEN, H. J., 1917. The origin and distribution of agriculture in America. 19th International Congress of Americanists. Pp. 69-76. Washington.

——— 1928. Ancient civilizations of Mexico and Central America. American Museum of History, Handbook No. 3, 3rd. ed. New York.

STEBBINS, C. L., 1950. Variation and Evolution in Plants. Columbia University Press. New York.

STEPHENS, S. G., 1948. A comparative developmental study of a dwarf mutant in maize, and its bearing on the interpretation of the tassel and ear structure. Ann. Mo. Bot. Gard. 35:289-299.

STRONG, WILLIAM DUNCAN, 1957. Paracas, Nazca and Tiahuanacoid cultural relationships in the South Coast of Peru. Memoirs of the Soc. for American Archaeology No. 13. American Antiquity 22: (No. 4 Part. 2).

STRONG, W. D., and EVANS, JR. C. E., 1952. Cultural Stratigraphy in the Viru Valley, Northern Peru. Columbia University Press. New York.

STURTEVANT, E. L., 1899. Varieties of corn. U. S. Dept. Agr. Off. Exp. Sta. Bul. 57.

TING, Y. C., 1960. Cytological observations on two tropical forms of *Tripsacum.* Bot. Mus. Leafl. Harvard University 19:97-108.

TOWLE, MARGARET A., 1948. Report on the plant remains from Pachacamac (Unpublished).

——— 1952a. Descriptions and Identifications of the Viru Plant Remains. *In* Strong, Wm. Duncan and Evans, Clifford, Jr. Cultural Stratigraphy in the Viru Valley, Northern Peru. Pp. 352-256. Columbia University Press. New York.

——— 1952b. Plant remains from a Peruvian mummy bundle. Bot. Mus. Leafl. Harvard University. 15:223-246.

——— 1954. Plant remains. *In* Willey. Gordon R. and Corbett, John M. Early Ancon and Supe Culture. 130-138. Columbia University Press. New York.

——— 1956. Descriptions and identifications of plant materials from the South Coast of Peru. Manuscript. Harvard University. Cambridge.

——— 1961. The Ethnobotany of Pre-Columbian Peru as evidenced by Archaeological materials. Viking Fund Publ. in Anthropology No. 30. Quadrangle Books. Chicago.

TSCHUDI, J. J. VON, 1847. Travels in Peru during the years 1838-1842. David Bogue. London.

UHLE, MAX, 1925. Report on Exploration at Supe. University of California Publications in American Archaeology and Ethnology. 21:257-264.

VALCARCEL, LUIS EDUARDO, 1946. The Andean calendar. *In* Handbook of South American Indians. *Ed.* J. H. Steward. Bulletin 143, Bureau of American Ethnology. Volume 2:471-476.

VALVERDE, FRAY VICENTE, 1865. Carta dirigida al emperador Carlos V. Coleccion de documentos ineditos relativos al descubrimiento, conquista y colonizacion de las posesiones españolas en America y Oceania. Madrid. Volume III.

Vavilov, N. I., 1931. Mexico and Central America as the principal centres of origin of cultivated plants of the New World. Bull. Appl. Bot. Genet., Plant Breeding (Leningrad) 26:135-200.

—————— 1950. The Origin, variation, immunity and breeding of cultivated plants. Tr. from the Russian by K. S. Chester. Chronica Botanica. Nr. 1/6.

Weatherwax, F., 1936. The origin of the maize plant and maize agriculture in ancient America. Univ. N. Mex. Bul. 296: 11-18.

—————— 1942. The Indian as a corn breeder. Proc. Indiana Acad. Sci. 51:13-21.

—————— 1954. Indian corn in Old America. The Macmillan Company. New York.

Weberbauer, A., 1936. Phytogeography of the Peruvian Andes. *In* J. P. MacBride. Flora of Peru. Part. I. Field Museum of Natural History. Publication 351. pp. 13-81. Chicago.

—————— 1945. El Mundo Vegetal de los Andes Peruanos. Ministerio de Agricultura. Lima.

Wellhausen, E. J., Fuentes O., Alejandro, Hernandez Corzo, Antonio, *in collaboration with* Mangelsdorf, P. C., 1957. Races of maize in Central America. Natl. Acad. Sci.-Natl. Res. Council Publ. No. 511.

Wellhausen, E. J., and Prywer, C., 1954. Relationship between chromosome knob number and yield in corn. Agron. Jour. 46:507-511.

Wellhausen, E. J., Roberts, L. M., Hernandez, X. E., *in collaboration with* Mangelsdorf, P. C., 1952. Races of Maize in Mexico. Bussey Inst., Harvard University. Cambridge.

Whitaker, T. W., and Bird, J. C., 1949. Identification and significance of the cucurbit materials from Huaca Prieta, Peru. Amer. Mus. Novitates, No. 1426, 15 pp.

Willey, G. R., 1949. Ceramics (A cross-cultural survey of South American Indian tribes). *In* Handbook of South American Indians. *Ed.* J. H. Steward. Bulletin 143, Bureau of American Ethnology. Volume 5:139-204.

————— 1950. Growth trends in New World Cultures. *In* For the Dean, Essays in Honor of Byron Cummings, Santa Fe. New Mexico.

—————— 1953. Prehistoric settlement patterns in the Viru valley in Peru. Bureau American Ethnology. Bull. 155.

—————— 1955. The Prehistoric Civilizations of Nuclear America. Amer. Anthrop. 57:571-593.

—————— 1960. New World Prehistory. Science 131:78-86.

Willey, G. R., and Corbett, J. M., 1954. Early Ancon, and Early Supe Culture Chavin Horizon sites of the Central Peruvian Coast. Columbia University Press. New York.

Wittmack, L., 1888. Die Naturflanzen der Alten Peruanes. Congress International de Americanistes. 7:325-349. Berlin.

Wright, Sewall, 1931. Evolution in Mendelian populations. Genetics 16:97-159.

Yacovleff, E., and Herrera, F. L., 1934-1935. El Mundo vegetal de los antiguos peruanos. Revista del Museo Nacional. 3:241-322, 4:29-102.

Zapparoli, T. V., 1925. Broken seeds in maize. Jour. Heredity 16:259-262.

APPENDIX

TABLE 1A. Average Measurements of Ear Characters of Prehistoric Races from Pottery Moldings.

		Ear Characters						
Race	*Period*	*Length (cm)*	*Width (cm)*	*Rows of Kernels*	*No. of Kernels in row*	*Kernel Width (mm)*	*Kernel Thickness (mm)*	*Imbrication*
Confite Puntiagudo	Mochica	5.8	3.8	Ir.	—	—	—	2–3
Kculli	Mochica	4.0	1.9	Ir.	10.0	—	—	0
Mochero	Mochica	4.5	2.0	Ir. 10–12	13.5	6.3	4.8	0–1
Pagaladroga	Mochica	9.7	3.0	Ir. 16	24.0	4.8	4.0	1–2
Rabo de Zorro	Mochica	9.9	Base 2.4 Center 1.8	8	24.4	6.9	4.2	—
Ancashino	Mochica	9.3	3.2	14–16	19.0	6.0	4.0	0–1
Alazan	Mochica	8.2	2.5	10	20.3	5.5	3.6	1
Chancayano	Mochica	6.9	2.1	10	18.0	7.5	3.0	1
Kculli	Chimu	4.3	2.0	Ir. 10–12	—	—	—	1–2
Ancashino	Chimu	8.6	3.4	12	21.0	7.0	4.0	1
Cuzco	Chimu	9.4	2.4	8	21.0	6.0	3.0	1
Confite Morocho	Inca	7.5	1.9	8	17.0	6.0	4.0	1–2

Ir = Irregular.

TABLE 2A. Plant Characters.

Races	*Range of Altitude (meters)*	*Days to Flowering*	*Height (cm)*		*Ear Position (node)*	*Stalk Diameter (mm)*	*Prop Roots*	*Tillers*	*Pubescence*	*Color*	*Seedling Color Index*
			Plants	*Ears*							
PRIMITIVE RACES.											
Confite Morocho	2500–3000	116	127	56	3	16.0	0.05	0	0.7 M	DSR–SR	4.50
Confite Puntiagudo	2500–3500	125	116	49	6	16.7	0.01	0	0.7 M	DSR	4.25
Kculli	2300–3300	137	92	29	—	19.0	0	0	0	P–SR	3.00
Confite Puneño	3600–3900	91	56	12	2	10.0	0	0	0.5 M	SR–P	3.00
Enano	— —	—	136	83	—	19.4	0.20	—	1.3 M	G	—
ANCIENTLY DERIVED RACES.											
Huayleño	2500–3600	138	118	87	8	20.1	0.28	0	0.5	DSR	2.86
Chullpi	2350–3400	144	200	76	8	19.5	0.07	0.012	0.4	SR	4.28
Granada	2600–3300	140	136	53	—	24.0	0.15	0	1.0 M	SR	3.28
Paro	2600–3300	144	124	38	4	17.0	0	0	0	SR	4.50
Morocho	2000–3500	143	154	91	6	20.5	0.25	0	0.5 M	DSR–SR	3.92
Huancavelicano	2200–3500	140	132	48	5	22.3	0	0	0.5 M	SR	6.00
Mochero	25– 50	69	153	93	6	18.3	0.14	0.05	2.0 S	G	4.75
Pagaladroga	10– 500	83	207	114	6	19.7	1.35	0.1	2.0 M	G	4.00
Chaparreño	10– 500	83	172	98	6	23.5	0.90	0	1.0 M	G	—
Rabo de Zorro	2600–3200	115	171	90	7	18.2	0.37	0	1.0 M	DSR	1.50
Piricinco	150–1000	96	166	101	8	18.3	0.87	0.06	1.3 M–S	DSR	0.77
Ancashino	2700–3100	143	138	75	7	18.8	0.16	0	0.5	DSR	1.57
Shajatu	2300–2800	155	152	80	8	21.5	0.20	0	0	DSR	1.60
Alazan	15– 100	93	214	138	8	21.2	0.74	0.23	1.3 M	G	3.25
Sabanero	2500–2600	151	230	174	7	22.1	0.35	0.05	1.1 M	SR	2.00
Uchuquilla	2100–2500	129	133	55	—	14.0	0.25	0	0.8 M	SR	2.50
Cuzco Cristalino Amarillo	2500–3300	133	157	73	3	23.0	0.30	0	0.4	DSR–SR	3.20
Cuzco	2400–3300	141	164	65	7	23.6	0.20	0	0.5	DSR	1.00
Pisccorunto	2900–3100	128	107	33	7	18.0	0	0.2	0.5	P–DSR	—

TABLE 2A. Plant Characters (Continued).

Races	Range of Altitude (meters)	Days to Flowering	Height (cm) Plants	Height (cm) Ears	Ear Position (node)	Stalk Diameter (mm)	Prop Roots	Tillers	Pubescence	Color	Seedling Color Index
LATELY DERIVED RACES.											
Arequipeño	10–2000	90	197	98	6	17.1	0.20	0	1.0 A–M	DSR	7.00
Huachano	40– 50	84	196	108	7	19.5	0.75	0.05	1.5	G	3.00
Chancayano	40– 100	96	192	99	6	26.0	0.90	0.6	1.5 M–S	G	2.50
San Geronimo Huancavelicano	2500–3500	134	114	50	5	17.0	0	0	0.5	SR	3.66
Perla	10– 900	97	225	130	7	23.7	1.08	0.05	1.0 M–S	SR	3.73
Rienda	10– 500	113	274	184	9	26.1	0.80	0	1.0 M	DSR–G	—
Marañon	2000–3000	120	204	110	8	27.1	0.89	0.016	0.7 S	DSR	1.36
Chimlos	1500–2300	153	233	181	10	23.5	2.10	0.05	2.0 M–S	G	2.00
Cuzco Gigante	2800–3400	141	132	50	—	23.6	0	0	0	DSR	6.00
INTRODUCED RACES.											
Pardo	10– 800	99	204	115	7	19.7	0.20	0.1	1.0 S	G	0
Aleman	700–2200	104	193	107	7	20.0	2.60	0.1	1.0 M	G	5.50
Chuncho	1300–2700	141	269	181	7	25.9	0.98	0	1.5 M	DSR	2.66
Arizona	25–2200	95	191	108	9	21.9	0.57	0.025	1.0 M	G	2.50
INCIPIENT AND IMPERFECTLY DEFINED RACES.											
Jora	— —	—	159	132	7	24.8	0.80	0.2	1.0 M–S	G	4.00
Coruca	— —	—	145	121	8	22.0	1.40	0	1.0 S	G	2.00
Morocho Cajabambino	— —	—	175	84	—	23.0	0.13	0	0.3	RS	2.00
Morado Canteño	— —	—	128	60	—	17.0	0	0	0	RS	4.00
Sarco	— —	—	139	54	—	19.6	0	0	As	RSd	5.50
Perlilla	— —	—	232	142	—	29.0	0.20	0	1.0	RSd	4.00

TABLE 3A. Leaf Characters.

Races	*No. of Leaves*	*No. of Leaves above Ear*	*Length (cm)*	*Width (cm)*	*Area (cm2)*	*Venation Index*	*Leaf Pattern Index Quadrant*				*Susceptibility to*	
							I	*II*	*III*	*IV*	*Rust*	*Helminthosporium*
PRIMITIVE RACES.												
Confite Morocho	11.9	5.6	53.4	6.3	2674	3.80	9.3	42.4	16.4	31.9	2.7	1.5
Confite Puntiagudo	8.7	4.2	56.2	6.5	2356	3.69	0	31.0	31.6	37.7	1.8	2.9
Kculli	9.5	5.3	58.0	7.4	4707	3.31	0	85.0	0	15.0	1.3	2.5
Confite Puneño	5.8	4.6	52.3	5.7	863	2.46	6.7	0	93.2	0	2.7	2.2
Enano	12.5	6.2	73.7	7.7	—	2.92	—	—	—	—	1.1	1.8
ANCIENTLY DERIVED RACES.												
Huayleño	10.7	5.3	61.6	7.7	5070	3.20	0	94.4	0	5.6	3.0	2.5
Chullpi	10.4	5.1	72.0	8.2	3905	3.33	0	42.5	18.3	39.2	2.1	3.5
Granada	10.4	5.4	66.6	6.9	—	3.10	18.9	32.2	24.2	24.6	2.5	2.1
Paro	9.3	4.5	36.2	6.9	4261	3.46	6.7	89.1	0	4.2	2.0	1.7
Morocho	9.6	4.7	59.0	8.7	5080	3.58	0	100.0	0	0	2.2	2.1
Huancavelicano	10.9	5.1	55.1	8.3	2900	3.04	24.0	53.0	16.4	6.5	2.0	1.0
Mochero	10.4	3.8	75.8	8.8	2410	2.74	2.6	21.6	57.3	18.4	1.2	1.3
Pagaladroga	11.6	5.5	76.2	9.7	3701	2.54	2.8	49.1	26.3	21.8	2.0	2.0
Chaparreño	12.1	5.1	90.2	9.2	6146	2.67	0	90.0	0	10.0	1.7	1.0
Rabo de Zorro	11.8	5.2	61.1	8.7	3180	2.78	18.9	44.9	23.1	13.0	2.0	2.0
Piricinco	12.3	5.2	77.9	9.3	3723	2.60	24.8	39.4	35.6	0.2	1.2	1.1
Ancashino	10.5	5.4	55.9	8.2	4035	2.68	3.4	52.6	1.8	42.2	3.4	2.1
Shajatu	9.5	5.1	63.5	7.4	5167	3.17	13.0	69.6	0.7	16.8	3.0	3.0
Alazan	12.7	4.9	87.2	9.9	5757	2.70	6.3	48.6	30.0	15.1	1.2	1.0
Sabanero	12.3	4.5	86.7	9.5	4890	2.50	0	73.6	0	26.3	2.5	2.5
Uchuquilla	7.0	4.0	58.7	7.7	—	3.98	—	—	—	—	3.0	2.7
Cuzco Cristalino Amarillo	11.3	5.9	73.8	9.4	4246	2.80	10.2	37.3	43.1	9.3	2.2	2.3
Cuzco	10.6	6.9	64.3	8.9	4969	2.70	3.5	77.8	0	18.7	1.9	2.4
Pisccorunto	11.9	5.4	76.2	7.4	5817	2.46	14.2	56.4	13.5	15.8	2.3	2.2

TABLE 3A. Leaf Characters (Continued).

Races	No. of Leaves	No. of Leaves above Ear	Length (cm)	Width (cm)	Area (cm2)	Venation Index	Leaf Pattern Index Quadrant				Susceptibility to	
							I	II	III	IV	Rust	Helminthosporium
LATELY DERIVED RACES.												
Arequipeño	11.2	5.6	81.0	9.1	4060	2.20	4.5	73.6	0.4	21.5	1.7	2.5
Huachano	12.6	5.6	81.9	9.5	4423	2.58	10.1	48.0	27.1	14.7	1.0	1.0
Chancayano	13.1	5.4	87.0	10.2	7193	2.36	4.8	89.2	0	5.9	1.0	1.0
San Geronimo Huancavelicano	9.8	5.6	55.1	6.6	1245	3.50	12.9	87.1	0	0	3.0	2.7
Perla	13.7	5.6	94.4	10.6	8529	2.50	0	96.6	0	3.4	1.0	1.0
Rienda	14.0	6.0	70.6	9.1	5116	2.64	18.9	44.3	25.9	10.9	2.0	1.5
Marañon	11.7	5.0	76.0	9.1	4903	2.70	22.6	38.6	25.3	13.5	1.9	1.9
Chimlos	14.2	5.1	76.9	9.7	10771	2.51	33.0	66.2	0.8	0	1.3	1.0
Cuzco Gigante	10.5	5.2	51.8	7.6	5184	3.00	11.0	62.3	14.5	12.3	3.0	3.0
INTRODUCED RACES.												
Pardo	11.9	4.5	81.3	8.9	8077	2.30	7.1	79.0	13.2	0.8	1.0	1.0
Aleman	14.6	5.5	85.3	9.7	6746	2.90	17.9	76.0	6.1	0	1.0	1.0
Chuncho	14.9	6.2	82.4	10.5	6676	2.70	6.9	58.9	30.0	4.3	1.7	1.7
Arizona	10.5	5.4	55.9	8.2	5831	2.70	1.1	73.4	14.7	10.9	1.5	1.7
INCIPIENT AND IMPERFECTLY DEFINED RACES.												
Jora	13.5	5.1	83.2	9.9	7153	2.62	0	100.0	0	0	1.0	1.0
Coruca	13.6	6.3	91.0	10.4	8140	2.10	9.1	43.6	15.9	31.3	1.5	1.2
Morocho Cajabambino	10.4	4.9	58.1	7.9	—	3.03	—	—	—	—	1.8	2.3
Morado Canteño	12.5	5.5	53.5	7.2	—	3.20	—	—	—	—	1.5	0
Sarco	11.1	5.4	40.3	6.5	—	3.58	—	—	—	—	0.7	1.7
Perlilla	12.0	4.4	84.0	9.8	—	2.90	—	—		—	2.2	2.0

TABLE 4A. Tassel Characters.

Races	Length of Peduncle (cm)	Tassel Length (cm)	Length of Terminal Spike (cm)	Length of Branching Space (cm)	Percentage of Branching Space	Length of Upper Branch (cm)	*Largest Branch*			Number of Primary Branches	Number of Secondary Branches	Number of Tertiary Branches	Condensation Index
							Length (cm)	Number of Secondaries on	Number of Tertiaries on				
PRIMITIVE RACES													
Confite Morocho	27.2	28.7	19.3	9.4	32.7	12.4	19.7	1.5	0.1	10.7	4.2	0.1	1.00
Confite Puntiagudo	20.0	24.7	15.6	9.1	36.8	10.5	17.2	0.8	0	9.0	2.8	0	1.02
Kculli	19.6	27.2	18.3	8.8	22.1	11.5	16.3	1.3	0	10.3	2.3	0	1.00
Confite Puneño	22.4	18.7	14.3	4.4	23.5	9.2	12.2	0.1	0	5.9	0.1	0	1.00
Enano	14.0	—	—	—	—	—	—	—	—	—	—	—	—
ANCIENTLY DERIVED RACES.													
Huayleño	19.5	19.1	10.8	8.2	43.5	8.6	13.3	0.9	0	14.9	3.3	0	1.01
Chullpi	18.0	28.5	13.9	14.6	51.2	10.6	18.4	1.2	0	18.0	4.5	0	1.00
Granada	18.2	27.7	14.1	13.6	49.1	9.4	19.8	2.0	0	15.2	9.5	0	1.02
Paro	25.5	33.0	21.0	12.0	36.4	14.0	18.8	0.5	0	11.5	5.5	0	1.03
Morocho	21.0	24.8	17.0	7.8	31.5	10.6	14.9	0.5	0	9.9	2.0	0	1.00
Huancavelicano	14.0	28.7	19.5	9.2	32.0	12.2	18.2	1.3	0	11.8	3.0	0	1.02
Mochero	11.4	37.9	21.1	16.8	44.3	14.5	25.0	2.2	0.7	23.6	15.2	2.7	1.09
Pagaladroga	17.4	33.7	17.5	16.2	48.7	12.9	22.7	2.7	0.5	21.5	11.3	0.7	1.08
Chaparreño	9.6	43.1	20.8	15.8	38.1	14.2	22.9	2.5	0.5	25.8	14.2	1.5	1.00
Rabo de Zorro	16.0	32.8	17.2	15.6	47.6	13.7	24.0	3.1	0.9	16.0	12.6	1.5	1.04
Piricinco	12.6	35.5	17.6	17.9	50.4	12.4	23.2	2.6	0.3	25.0	11.0	0.6	1.04
Ancashino	20.0	25.2	14.6	10.6	42.1	8.1	16.3	1.7	0.3	15.7	6.3	0.2	—
Shajatu	16.5	36.4	19.5	16.9	46.4	16.7	22.0	2.6	0.4	18.8	12.7	0.8	1.00
Alazan	12.0	36.9	20.3	16.6	44.9	15.0	23.5	3.0	0.7	23.6	12.0	1.1	1.10
Sabanero	19.3	34.1	17.8	16.3	47.8	12.3	17.5	2.4	0.3	16.3	8.8	0.4	1.00
Uchuquilla	19.5	40.5	24.0	16.5	40.7	16.9	26.9	2.6	0.2	17.5	9.0	0.2	1.00
Cuzco Cristalino Amarillo	22.5	30.8	16.9	13.9	45.1	13.2	20.5	1.6	0	12.6	6.3	0	1.00
Cuzco	18.0	29.3	17.4	11.9	40.5	10.4	18.2	1.1	0	12.9	4.6	0	—
Pisccorunto	18.5	—	—	8.3	—	—	—	1.0	0	7.8	—	—	—

TABLE 4A. Tassel Characters (Continued).

Races	Length of Peduncle (cm)	Tassel Length (cm)	Length of Terminal Spike (cm)	Length of Branching Space (cm)	Percentage of Branching Space	Length of Upper Branch (cm)	Largest Branch			Number of Primary Branches	Number of Secondary Branches	Number of Tertiary Branches	Condensation Index
							Length (cm)	Number of Secondaries on	Number of Tertiaries on				
LATELY DERIVED RACES.													
Arequipeño	13.5	32.0	16.9	15.1	47.2	12.4	20.8	3.4	0.6	18.4	13.5	1.1	—
Huachano	12.0	40.2	22.8	17.4	43.3	15.8	27.4	2.1	0.5	19.2	11.6	1.1	1.03
Chancayano	14.3	42.4	27.0	15.4	36.3	20.8	28.7	1.9	0.7	18.8	9.5	0.7	1.06
San Geronimo Huancavelicano	21.0	23.2	11.6	11.6	50.0	7.6	9.3	1.2	0.1	15.0	3.8	0.2	1.00
Perla	12.1	39.3	22.8	16.5	42.0	16.6	27.2	1.9	0.5	20.8	8.0	0.6	1.07
Rienda	19.0	43.3	22.5	20.8	48.0	17.5	20.3	4.5	0.7	20.5	19.3	0	1.05
Marañon	17.3	36.2	21.2	15.0	41.4	15.6	25.3	2.2	0.7	18.6	9.3	1.5	1.03
Chimlos	15.9	34.2	18.4	15.8	46.2	14.4	22.6	2.4	0.5	23.7	10.4	0.6	1.08
Cuzco Gigante	16.8	36.0	22.2	13.8	38.3	16.1	23.6	1.5	0.5	12.3	4.7	0.7	1.01
INTRODUCED RACES.													
Pardo	11.4	46.2	28.5	17.7	38.3	21.6	34.2	1.4	0.2	12.9	8.1	1.0	1.00
Aleman	13.0	36.4	21.2	15.2	41.7	18.1	28.5	2.3	0.3	20.4	8.0	0.3	1.01
Chuncho	15.1	36.0	19.1	16.9	46.9	14.1	23.0	2.1	1.0	24.9	10.9	1.7	1.07
Arizona	17.6	36.1	24.0	12.1	33.5	15.4	24.4	1.6	0	16.5	5.3	0.1	1.12
INCIPIENT AND IMPERFECTLY DEFINED RACES.													
Jora	16.5	43.6	26.4	17.2	39.4	20.4	31.5	1.9	0.6	21.1	8.6	1.2	1.08
Coruca	24.0	39.0	19.8	19.2	49.2	12.4	20.7	3.4	1.2	23.8	19.2	2.2	1.00
Morocho Cajabambina	15.0	27.4	15.9	11.5	—	13.1	22.9	1.4	0	15.8	5.6	0	2.00
Morado Canteño	16.9	37.6	24.3	13.3	—	18.9	25.0	0.9	0	12.8	5.6	0	1.00
Sarco	21.6	23.1	12.1	11.0	—	7.1	14.8	1.1	0	13.6	4.4	0	2.00
Perlilla	24.0	—	—	—	—	—	—	—	—	—	—	—	—

TABLE 5A. Ears External Characters.

	Ear						*Shank*			*Characters of the Kernels*					
Races	*Length (cm)*	*Width (cm)*	*Diameter Tip (cm)*	*Diameter Base (cm)*	*Row Number*		*Length (cm)*	*Diameter (cm)*	*Number of Internodes*	*Length (mm)*	*Width (mm)*	*Thickness (mm)*	*Denting*	*Striation*	*Hardness*
PRIMITIVE RACES.															
Confite Morocho	6.78	2.32	2.17	2.69	10.66		5.17	0.42	4.8	7.34	5.87	4.55	1.00	1.00	2.66
Confite Puntiagudo	8.86	3.24	2.87	3.34	15.13		7.70	—	4.9	8.26	5.55	4.33	0	0	1.97
Kculli	9.23	4.71	3.38	4.71	12.00		6.14	0.88	5.5	13.78	10.27	6.01	0	1.00	2.60
Confite Puneño	6.58	3.45	3.80	4.46	16.00	Irreg.	—	0.90	—	9.19	6.74	4.98	0.30	0.90	2.12
Enano	7.22	2.50	2.01	2.70	—		—	—	—	6.20	5.30	3.70	0.40	1.80	—
ANCIENTLY DERIVED RACES.															
Huayleño	11.63	4.93	3.60	4.20	8.60		4.82	1.00	4.7	13.00	7.90	5.30	0	0	2.60
Chullpi	8.64	4.63	5.28	5.86	18.00	Irreg.	6.46	0.73	5.3	16.50	8.00	4.30	3.00	0	2.27
Granada	8.58	5.16	3.50	4.18	—	Irreg.	6.75	1.03	4.5	13.10	9.70	6.00	0.16	0.50	1.54
Paro	11.49	5.84	3.64	4.67	14.66		5.25	1.13	4.32	15.07	8.94	5.14	—	—	—
Morocho	12.15	4.25	3.05	3.73	10.75		4.30	0.93	4.70	11.71	9.76	5.65	0	0.10	1.90
Huancavelicano	11.45	4.50	3.65	4.70	8.75		6.65	1.01	4.32	15.00	11.60	6.20	0	1.70	2.54
Mochero	7.63	4.13	3.73	4.06	—	Irreg.	6.50	—	8.89	9.90	7.60	4.50	0.77	1.45	—
Pagaladroga	14.31	4.19	2.75	3.70	15.00		7.75	1.10	7.00	9.60	7.80	4.10	0.50	0.90	1.50
Chaparreño	10.48	4.22	3.65	4.28	14.00		7.14	0.88	5.66	11.00	8.40	4.40	0.50	1.00	3.00
Rabo de Zorro	18.45	3.98	2.60	3.50	10.40		8.14	1.12	6.39	12.79	7.90	5.69	0	0	2.10
Piricinco	24.02	3.71	2.48	3.63	10.00	Irreg.	9.83	1.57	7.29	8.10	7.80	5.10	0.05	0.40	1.15
Ancashino	13.26	5.40	3.62	5.28	13.75		5.99	1.06	4.75	13.10	8.40	5.30	0	0	2.59
Shajatu	10.25	4.79	3.60	4.50	16.30		8.20	0.75	6.00	12.00	7.80	5.00	0.16	0	3.00
Alazan	15.84	4.90	3.95	4.30	14.15		6.87	1.34	7.00	10.60	9.20	4.80	1.51	1.36	2.38
Sabanero	13.65	4.60	3.22	4.63	10.05		5.60	1.18	4.60	13.00	11.70	5.00	0.50	0.50	2.50
Uchuquilla	16.72	4.53	2.86	3.29	9.46		13.10	1.04	7.70	13.71	11.30	4.42	0.20	0.70	2.50
Cuzco Cristalino Amarillo	13.20	4.88	3.23	3.84	8.42		8.24	1.14	5.36	15.02	12.69	5.16	0.35	0.25	2.85
Cuzco	12.80	4.17	3.77	4.60	8.30		8.86	1.07	4.80	15.40	13.20	5.40	0.77	0.37	2.25
Piscorunto	11.80	5.15	4.00	4.97	12.00		11.64	—	5.40	17.00	11.20	5.20	0.33	0.33	3.00

TABLE 5A. Ears External Characters (Continued).

	Ear						Shank			Characters of the Kernels					
Races	Length (cm)	Width (cm)	Diameter Tip (cm)	Diameter Base (cm)	Row Number		Length (cm)	Diameter (cm)	Number of Internodes	Length (mm)	Width (mm)	Thickness (mm)	Denting	Striation	Hardness
LATELY DERIVED RACES.															
Arequipeño	13.04	5.17	3.55	5.37	10.67		—	0.95	—	13.90	11.90	4.50	2.50	3.00	2.15
Huachano	14.70	4.61	4.14	5.00	10.96		6.18	0.94	6.38	11.47	10.78	4.46	1.80	1.70	2.87
Chancayano	14.78	5.27	4.15	5.11	11.66		7.97	—	7.90	11.80	11.40	4.80	1.44	1.33	2.50
San Geronimo Huancavelicano	8.10	4.70	4.10	5.20	11.12		4.70	1.00	4.50	16.10	11.60	5.50	1.00	0.50	1.93
Perla	18.35	4.98	3.60	4.74	15.64		7.17	1.56	8.69	9.80	8.80	5.00	0.20	1.53	1.29
Rienda	16.90	3.47	2.86	3.62	14.00		9.80	0.83	5.30	9.50	7.20	4.60	1.00	1.45	—
Marañon	16.68	4.98	3.07	4.33	14.98	Irreg.	8.58	1.07	5.79	13.50	8.54	5.60	0.25	0.37	3.00
Chimlos	22.65	3.62	3.29	4.51	14.00		4.50	1.34	2.50	10.98	7.49	5.56	0.50	0.50	3.00
Cuzco Gigante	14.90	5.62	4.27	5.93	8.31		5.46	1.09	4.07	20.20	16.20	6.00	0.50	0.25	2.66
INTRODUCED RACES.															
Pardo	19.66	4.20	3.20	3.83	7.80		9.62	0.90	8.20	12.10	12.30	4.50	1.90	1.30	3.00
Aleman	13.06	4.53	4.07	4.98	13.00	Irreg.	7.13	1.33	6.77	11.10	8.60	5.00	1.00	0.50	2.00
Chuncho	17.76	5.37	4.20	5.21	15.17		11.17	1.60	11.33	12.60	8.50	4.90	1.41	0.52	2.60
Arizona	17.41	5.22	4.04	5.07	14.24		7.63	1.55	9.38	11.70	9.70	5.10	2.28	1.00	1.87
INCIPIENT AND IMPERFECTLY DEFINED RACFS															
Jora	17.40	5.05	3.84	4.86	14.50		8.02	0.73	9.60	12.20	9.00	4.50	1.20	0.80	3.00
Coruca	14.13	6.08	4.07	5.97	10.60		9.14	1.17	5.40	18.50	12.30	5.00	3.00	2.00	2.33
Morocho Cajabambino	14.15	3.60	3.20	3.84	10.67		5.52	0.89	5.10	10.68	9.30	5.71	—	—	—
Morado Canteño	12.90	4.65	—	—	11.00		—	0.79	—	12.64	10.29	4.76	—	—	—
Sarco	12.09	4.56	3.88	4.79	—		7.68	0.73	5.73	14.09	10.01	9.26	—	—	—
Perlilla	11.10	4.17	—	—	—	Irreg.	6.50	0.84	6.40	10.20	6.62	4.96	—	—	—

TABLE 6A. Frequencies of Pericarp and Cob Color Phenotypes per Race.

Pericarp-Cob	Cherry-Purple	Cherry-Red	Red-Red	Red-Purple	Red-White	Colorless-Red	Red White Cap-Red	Red White Cap-Purple	Red White Cap-White	Variegated Red-Variegated Red	Mosaic Red-Mosaic Red	Brown Red-Red	Brown Red-Brown Red	Brown Red-Purple	Brown Red-White	Brown-Brown	Light Brown-Light Brown	Light Brown-White	Brown-White	Colorless-Brown	Brown White Cap-White	Brown White Cap-Brown	Variegated Brown-Brown	Mosaic Brown-Mosaic Brown	Mosaic Brown-White	Splashed Brown-Brown	Colorless-Purple	Colorless-White	Light Brown-Red	Variegated Brown-White	Orange-White	Orange-Red	Orange-Purple
Races	$AP^{rr}Plr^{ch}$	$AP^{rr\,ch}r$	AP^{rr}	$AP^{rr}Pl$	AP^{rw}	AP^{wr}	AP^{cr}	$AP^{cr}Pl$	AP^{cw}	AP^{vv}	AP^{mo}	$a^{p}{}'P^{rr}$	$a^{p}{}'P^{rr}$	$a^{p}{}'P^{r}Pl$	$a^{p}{}'P^{rw}$	$A^{b}{}'P^{rr}$	$A^{b}{}'P^{rr}$	$A^{b}{}'P^{rw}$	$A^{b}{}'P^{rw}$	$A^{b}{}'P^{wr}$	$A^{b}{}'P^{cw}$	$A^{b}{}'P^{cr}$	$A^{b}{}'P^{vv}$	$A^{b}{}'P^{mo}$	$A^{b}{}'P^{mo}$	$A^{b}{}'P^{?}$	?	?	?	$A^{b}{}'P^{vv}P^{ww}$ (?)	AP^{ow}	AP^{or}	$AP^{or}Pl$
	Percent																																
PRIMITIVE RACES.																																	
Confite Morocho	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	100.0	—	—	—	—	—
Confite Puntiagudo	—	—	—	—	—	5.3	—	—	—	3.1	—	—	—	—	—	—	4.6	—	3.1	—	—	—	—	—	—	—	—	84.0	—	—	—	—	—
Kculli	47.8	1.5	10.1	—	—	10.1	—	—	—	3.0	—	—	1.5	—	—	—	1.5	—	—	—	—	3.00	—	—	—	—	—	18.8	—	—	—	—	—
Confite Puneño	18.0	—	2.6	—	—	2.6	2.6	—	2.6	10.3	2.6	—	2.6	—	—	—	7.7	—	—	—	—	—	—	—	—	—	—	48.7	—	—	—	—	—
ANCIENTLY DERIVED RACES.																																	
Huayleño	2.6	—	11.0	1.50	—	4.9	5.1	1.00	3.1	2.0	1.5	0.30	5.6	0.30	0.3	16.1	13.6	3.1	1.8	0.5	0.3	2.00	1.80	—	1.0	0.80	0.8	18.7	0.3	0.3	—	—	—
Chullpi	—	—	2.6	—	—	9.3	—	—	—	5.3	5.3	—	—	—	—	—	13.3	2.6	—	—	—	1.30	—	—	—	—	—	58.6	—	—	—	—	—
Granada	2.0	—	7.1	—	2.0	9.2	6.1	2.50	4.6	7.7	1.0	—	2.0	—	—	8.2	6.6	0.5	0.5	—	0.5	2.00	0.50	0.5	—	—	—	34.7	1.5	—	—	—	—
Paro	—	—	1.8	—	—	17.8	1.8	1.80	1.8	5.4	1.8	—	1.8	—	—	7.1	1.8	1.8	—	—	—	—	—	1.8	—	—	—	53.5	—	—	—	—	—
Morocho	—	—	—	—	—	8.0	—	0.76	—	—	—	—	—	0.76	—	—	—	—	—	—	—	—	—	—	—	—	—	68.7	—	—	—	—	—
Huancavelicano	—	—	7.9	0.75	—	6.8	2.3	0.38	0.4	5.7	—	0.38	—	—	—	4.9	8.3	1.5	1.9	—	—	0.75	0.38	—	—	0.75	0.4	56.2	0.38	—	—	—	—
Mochero	—	—	7.7	—	2.6	5.1	7.7	2.60	2.6	15.4	—	—	—	—	—	12.8	—	—	—	—	—	—	—	—	—	—	—	43.6	—	—	—	—	—
Pagaladroga	—	—	70.0	—	—	—	10.0	—	—	—	—	—	—	—	—	20.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Chaparreño	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Rabo de Zorro	1.8	—	—	—	—	3.6	—	3.60	16.4	1.8	—	—	—	—	—	14.5	5.4	3.6	3.6	—	—	7.20	1.80	—	—	—	—	34.5	1.8	—	6.7	—	—
Piricinco	2.4	—	—	—	—	0.4	—	—	0.4	1.9	—	—	—	—	—	1.9	—	—	14.7	—	—	—	0.40	—	—	—	—	70.9	—	—	6.7	—	—
Ancashino	1.4	0.3	5.9	1.00	—	3.8	5.9	2.40	6.2	4.1	0.3	1.40	10.0	0.30	—	12.5	9.3	1.0	1.0	0.7	1.0	1.40	2.40	0.7	—	1.00	0.7	24.2	0.7	—	—	—	—
Shajatu	—	—	5.1	—	—	7.7	2.6	—	—	—	—	—	—	—	—	—	10.2	—	—	—	—	—	—	—	—	—	—	74.3	—	—	—	—	—
Alazan	1.2	—	57.6	—	1.2	—	3.5	—	16.5	1.2	—	—	—	—	—	8.2	—	—	3.5	—	3.5	—	—	—	—	—	—	3.5	—	—	—	—	—
Sabanero	—	—	2.9	—	2.9	8.8	—	—	—	2.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	79.4	2.9	—	—	—	—
Uchuquilla	—	—	—	—	—	7.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	38.5	—	—	23.1	7.7	23.1
Cuzco Cristalino Amarillo	0.7	0.7	5.5	0.70	—	45.8	5.5	—	0.7	3.5	0.7	—	0.7	—	—	3.5	9.0	—	1.4	1.4	—	1.40	—	—	—	3.50	—	13.9	1.4	—	—	—	—
Cuzco	—	—	1.5	—	—	—	9.2	—	1.5	—	1.5	—	—	—	—	—	—	—	—	1.5	—	—	—	—	—	—	—	84.6	—	—	—	—	—
Piscorunto	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	100.0	—	—	—	—	—

TABLE 6A. Frequencies of Pericarp and Cob Color Phenotypes per Race (Continued).

Pericarp-Cob Races	Cherry-Purple $AP^{rr}Plr^{ch}$	Cherry-Red $AP^{rr}r^{ch}$	Red-Red AP^{rr}	Red-Purple $AP^{rr}Pl$	Red-White AP^{rw}	Colorless-Red AP^{wr}	Red White Cap-Red AP^{cr}	Red White Cap-Purple $AP^{cr}Pl$	Red White Cap-White AP^{cw}	Variegated Red-Variegated Red AP^{vv}	Mosaic Red-Mosaic Red AP^{mo}	Brown Red-Red $a^{p}{}'P^{rr}$	Brown Red-Brown Red $a^{p}{}'P^{rr}$	Brown Red-Purple $a^{p}{}'P^{r}Pl$	Brown Red-White $a^{p}{}'P^{rw}$	Brown-Brown $A^{b}{}'P^{rr}$	Light Brown-Light Brown $A^{b}{}'P^{rr}$	Light Brown-White $A^{b}{}'P^{rw}$	Brown-White $A^{b}{}'P^{rw}$	Colorless-Brown $A^{b}{}'P^{wr}$	Brown White Cap-White $A^{b}{}'P^{cw}$	Brown White Cap-Brown $A^{b}{}'P^{cr}$	Variegated Brown-Brown $A^{b}{}'P^{vv}$	Mosaic Brown-Mosaic Brown $A^{b}{}'P^{mo}$	Mosaic Brown-White $A^{b}{}'P^{mo}$	Splashed Brown-Brown $A^{b}{}'P^{?}$	Colorless-Purple ?	Colorless-White ?	Light Brown-Red ?	Variegated Brown-White $A^{b}{}'P^{vv}P^{ww}$ (?)	Orange-White AP^{ow}	Orange-Red AP^{or}	Orange-Purple $AP^{or}Pl$
																	Percent																
LATELY DERIVED RACES.																																	
Arequipeño	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Huachano	—	—	—	—	—	26.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	73.1	—	—	—	—	—
Chancayano	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	100.0	—	—	—	—	—
San Geronimo Huancavelicano	—	—	6.3	—	—	16.4	1.8	—	—	4.5	0.9	—	—	—	—	2.7	3.6	0.9	—	—	0.9	—	—	—	—	—	—	61.8	—	—	—	—	—
Perla	—	—	1.6	—	—	12.4	0.5	—	0.5	—	—	—	3.1	—	—	—	—	—	—	0.5	—	—	—	—	—	—	—	42.5	—	—	36.3	2.6	—
Rienda	—	—	—	—	—	44.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	55.6	—	—	—	—	—
Marañon	—	—	5.5	—	—	6.4	3.7	—	2.7	13.8	1.8	0.90	0.9	—	—	9.2	1.8	2.7	5.5	—	1.8	4.60	1.80	0.9	—	—	—	35.8	—	—	—	—	—
Chimlos	—	—	40.0	—	—	—	—	—	—	10.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	50.0	—	—	—	—	—
Cuzco Gigante	8.3	—	6.6	—	—	4.9	9.1	—	0.8	8.3	6.6	—	0.8	—	—	0.8	2.5	—	2.5	—	—	1.70	—	—	—	—	—	47.1	—	—	—	—	—
INTRODUCED RACES.																																	
Pardo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	100.0	—	—	—	—	—
Aleman	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	100.0	—	—	—	—	—
Chuncho	—	—	2.3	—	—	2.3	18.6	2.30	23.3	2.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	48.8	—	—	—	—	—
Arizona	—	—	—	—	—	2.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	98.0	—	—	—	—	—
INCIPIENT AND IMPERFECTLY DEFINED RACES.																																	
Jora	—	—	—	—	—	30.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	70.0	—	—	—	—	—
Coruca	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	16.6	—	—	—	—	—	—	—	—	—	—	—	50.0	—	16.6	—	—	—
Morocho Cajabambino	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Morado Canteño	100.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Perlilla	—	—	—	—	—	60.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	40.0	—	—	—	—	—

TABLE 7A. Zygotic Frequencies of Pericarp and Cob Color Alleles for some Departments of Peru, Based on Visual Scoring.

	Ancash	*Apurimac*	*Ayacucho*	*Cajamarca*	*Cuzco*	*Huancavel*	*Junin*	*Puno*
A	0.465	0.552	0.300	0.700	0.800	0.566	0.639	0.806
$a^{p\prime}$	0.114	0.013	0.025	—	0.021	0.037	0.033	—
$a^{b}\,'$	0.421	0.434	0.675	0.300	0.177	0.397	0.328	0.193
P^{rr}	0.577	0.486	0.725	0.325	0.237	0.452	0.409	0.207
P^{rw}	0.044	0.105	0.050	0.150	0.029	0.105	0.098	—
P^{wr}	0.052	0.092	0.100	0.400	0.410	0.288	0.229	0.483
P^{cr}	0.179	0.144	0.025	—	0.187	0.037	0.098	0.010
P^{cw}	0.075	0.052	0.050	—	0.028	0.009	0.033	0.034
P^{vv}	0.031	0.092	—	0.125	0.072	0.082	0.131	0.172
P^{mo}	0.019	0.026	—	—	0.014	0.023	—	—
$P^{?*}$	0.021	—	0.050	—	0.022	0.005	—	—

* New P allele, undescribed yet.

TABLE 8A. Ears Internal Characters.

Races	Ear Diameter (mm)	Cob Diameter (mm)	Rachis Diameter (mm)	Pith Diameter (mm)	Rachilla Length (mm)	Cupule				Height Rachis Flaps	Rachis Induration	Indexes			Lower Glume			Upper Glume			
						Length (mm)	Width (mm)	Depth (mm)	Pubescence			Cob/ Rachis	Glume/ Kernel	Rachilla/ Kernel	Length (mm)	Pubescence	Texture	Length (mm)	Pubescence	Texture	Venation
PRIMITIVE RACES.																					
Confite Morocho	26.3	12.0	5.2	2.0	1.4	3.1	2.9	1.4	1.15	1.60	2.90	2.30	0.37	0.16	4.2	1.60	1.55	3.1	1.05	1.15	1.80
Confite Puntiagudo	33.5	21.6	12.6	6.5	1.7	1.6	5.1	1.4	1.50	1.50	3.30	1.71	0.52	0.19	4.8	1.53	3.15	4.0	1.20	1.86	1.85
Keulli	46.9	21.3	15.2	5.7	0.8	1.4	8.1	2.4	1.10	1.66	3.00	1.40	0.20	0.05	3.1	1.60	2.66	2.8	1.00	1.50	1.83
Confite Puneño	44.5	20.0	13.0	4.7	4.2	1.6	7.4	1.9	2.05	1.30	3.35	1.54	0.30	0.36	5.2	1.95	1.70	3.5	1.15	1.70	1.75
Enano	—	14.3	7.8	3.8	2.4	1.3	3.7	1.0	1.90	1.30	3.10	1.83	0.52	0.38	3.5	1.70	2.10	3.1	1.00	1.30	2.10
ANCIENTLY DERIVED RACES.																					
Huayleño	42.0	21.0	11.4	5.3	2.3	2.1	5.3	1.6	2.20	0.95	3.20	1.84	0.37	0.18	5.1	2.10	3.20	4.2	1.25	2.15	1.70
Chullpi	58.0	29.2	18.2	9.2	3.4	1.1	7.1	1.4	1.00	2.00	3.30	1.60	0.33	0.21	5.4	1.70	3.30	4.5	1.00	2.10	1.80
Granada	42.6	23.0	13.2	5.2	1.6	1.7	6.9	1.4	1.30	1.30	2.70	1.74	0.37	0.12	5.7	2.10	2.40	4.0	1.30	1.41	2.40
Paro	43.3	29.4	20.1	10.3	3.8	1.2	7.5	1.2	1.52	1.56	3.18	1.46	0.31	0.25	5.8	1.52	2.00	4.5	1.00	2.02	2.20
Morocho	37.3	22.4	13.2	6.4	1.0	2.2	8.2	2.4	1.50	1.65	3.12	1.69	0.42	0.09	6.3	1.24	3.10	3.1	1.10	2.00	1.25
Huancavelicano	46.5	20.5	13.0	7.0	1.7	1.7	10.8	1.5	1.50	1.00	3.50	1.58	0.25	0.11	4.2	2.00	3.00	3.0	1.00	2.00	2.50
Mochero	41.3	24.8	16.1	9.4	2.7	1.4	7.9	1.1	1.50	1.90	2.80	1.54	0.44	0.27	6.1	1.30	3.05	4.7	1.10	1.30	2.40
Pagaladroga	34.9	21.2	12.2	5.0	1.7	2.9	5.9	1.3	1.70	1.50	3.45	1.74	0.47	0.17	4.2	1.35	2.25	4.1	1.20	1.50	1.45
Chaparreño	41.1	23.0	14.1	7.9	2.5	1.5	6.5	1.3	1.83	1.83	3.30	1.65	0.40	0.22	3.6	1.83	3.00	2.9	1.16	1.16	2.00
Rabo de Zorro	34.8	17.8	8.2	3.1	1.8	3.2	4.6	1.8	1.31	1.62	3.06	2.17	0.42	0.15	5.7	1.62	1.56	4.8	1.06	1.37	1.68
Piricinco	30.5	18.8	10.0	4.9	2.1	3.5	4.1	1.5	2.50	1.77	3.32	1.88	0.54	0.26	6.2	2.50	3.17	3.6	2.90	1.77	1.65
Ancashino	49.5	24.5	16.8	10.1	3.0	1.6	6.7	2.1	1.40	1.50	3.10	1.46	0.29	0.23	6.2	1.80	2.90	3.8	1.06	2.00	2.25
Shajatu	44.0	25.6	14.9	6.1	2.5	2.1	6.2	1.4	1.91	1.00	3.16	1.72	0.45	0.21	5.6	1.40	3.25	4.7	1.00	2.00	1.50
Alazan	42.8	30.2	14.5	10.3	1.0	3.4	10.3	2.4	1.74	1.87	2.87	1.56	0.50	0.09	6.2	1.71	3.14	5.4	1.19	1.68	1.71
Sabanero	42.2	23.2	16.6	7.6	0.6	1.7	10.1	2.1	1.50	0.50	4.00	1.53	0.26	0.05	4.9	1.50	3.75	3.8	1.25	2.25	2.25
Uchuquilla	33.8	18.6	11.3	4.7	0.3	1.5	8.6	1.2	2.15	0.40	3.30	1.64	0.33	0.03	3.5	1.75	3.30	3.9	1.15	1.95	1.80
Cuzco Cristalino Amarillo	40.1	18.8	12.8	7.0	2.2	2.0	8.4	1.2	2.03	0.85	3.20	1.52	0.29	0.19	5.9	1.75	3.10	3.5	1.15	2.08	2.23
Cuzco	46.5	20.5	9.3	5.4	1.7	1.8	9.8	1.7	0.87	0.81	3.37	1.66	0.25	0.11	4.0	1.81	2.93	3.9	1.06	1.87	2.00
Pisccorunto	51.5	22.3	14.7	7.2	1.6	1.7	8.5	1.9	1.66	—	3.50	1.52	0.22	0.08	4.4	1.50	2.93	4.0	1.00	1.83	2.00

TABLE 8A. Ears Internal Characters (Continued).

						Cupule						Indexes			Lower Glume			Upper Glume			
Races	*Ear Diameter (mm)*	*Cob Diameter (mm)*	*Rachis Diameter (mm)*	*Pith Diameter (mm)*	*Rachilla Length (mm)*	*Length (mm)*	*Width (mm)*	*Depth (mm)*	*Pubescence*	*Height Rachis Flaps*	*Rachis Induration*	*Cob/ Rachis*	*Glume/ Kernel*	*Rachilla/ Kernel*	*Length (mm)*	*Pubescence*	*Texture*	*Length (mm)*	*Pubescence*	*Texture*	*Venation*
LATELY DERIVED RACES.																					
Arequipeño	51.7	28.0	19.0	9.7	2.5	1.2	10.0	1.2	1.75	1.00	3.75	1.47	0.32	0.18	5.2	1.75	4.00	4.2	1.25	2.00	1.25
Huachano	50.1	29.1	18.1	8.8	3.5	1.7	9.6	1.3	2.25	1.50	3.75	1.61	0.45	0.28	5.5	1.70	3.40	4.8	1.30	2.30	1.80
Chancayano	49.4	30.9	19.8	11.1	3.0	2.3	11.5	2.0	2.11	1.50	3.77	1.56	0.48	0.25	6.9	1.33	3.00	4.5	1.00	1 94	1.44
San Geronimo Huancavelicano	49.3	22.7	14.6	6.1	1.3	2.1	9.9	1.7	1.44	1.38	3.16	1.55	0.25	0.08	6.1	1.45	2.94	3.7	1.10	1.85	1.72
Perla	45.0	31.2	19.1	9.4	3.1	2.1	9.2	1.6	1.25	1.80	3.73	1.63	0.62	0.32	7.4	1.80	3.43	5.3	1.23	2.08	1.97
Rienda	34.7	18.5	8.5	2.7	3.6	3.4	4.1	1.6	1.90	1.45	2.90	2.17	0.53	0.38	5.1	1.75	2.00	4.8	1.15	1.40	1.50
Marañon	41.2	21.0	12.1	5.3	3.0	2.0	5.7	1.8	1.90	1.20	2.90	1.73	0.38	0.26	5.6	1.80	2.90	3.8	1.00	2.00	1.75
Chimlos	41.8	22.0	11.6	4.7	2.8	2.5	4.5	1.6	1.70	1.65	3.70	1.89	0.42	0.22	4.9	1.60	2.55	4.3	1.15	1.50	1.60
Cuzco Gigante	56.8	22.4	13.3	4.2	1.5	1.7	11.2	1.8	2.12	1.12	3.12	1.68	0.22	0.07	4.3	2.10	3.25	4.5	1.50	2.25	1.68
INTRODUCED RACES.																					
Pardo	38.6	20.6	12.0	4.1	1.2	1.9	7.9	1.4	2.30	1.40	3.90	1.71	0.35	0.10	5.7	1.25	3.05	4.4	1.20	1.25	1.60
Aleman	46.9	29.0	18.6	6.0	3.1	1.5	8.5	1.8	1.40	2.30	3.70	1.56	0.47	0.28	7.3	1.45	3.35	5.2	1.30	2.00	2.65
Chuncho	49.5	29.1	17.9	7.1	3.2	1.8	7.5	1.5	1.95	1.84	3.51	1.62	0.44	0.25	5.2	1.46	3.61	4.7	1.02	1.98	1.78
Arizona	49.9	34.6	23.4	13.3	1.5	2.1	10.9	1.6	1.50	1.78	4.00	1.48	0.48	0.13	6.5	1.57	3.62	5.7	1.25	2.16	2.00
INCIPIENT AND IMPERFECTLY DEFINED RACES.																					
Jora	50.1	31.0	21.7	12.3	2.0	1.5	9.2	1.6	1.90	1.20	3.10	1.43	0.38	0.16	5.8	1.15	3.40	4.6	1.05	1.50	1.95
Coruca	57.0	22.2	15.2	6.5	2.4	1.2	10.3	1.4	1.75	1.25	3.50	1.46	0.19	0.13	3.4	2.00	3.50	2.8	1.50	2.00	1.00

TABLE 9A. Frequencies of Endosperm Color and of Staminate Tips of Ears.

	Endosperm				
Races	*White*	*Yellow*	*White & Yellow*	*Yellow & White*	*Ears with Staminate Tips*
			Percent		
Confite Morocho	12	88	—	—	13
Confite Puntiagudo	68	21	7	7	20
Kculli	97	—	3	—	31
Confite Puneño	12	70	6	12	67
Huayleño	63	27	9	1	26
Chullpi	9	81	4	6	25
Granada	54	27	15	4	44
Paro	82	18	—	—	10
Huancavelicano	75	12	9	4	34
Rabo de Zorro	84	10	6	—	22
Piricinco	66	24	10	—	—
Ancashino	66	20	14	—	23
Shajatu	89	7	4	—	11
Sabanero	62	15	4	19	15
Uchuquilla	100	—	—	—	—
Cuzco Cristalina Amarillo	33	57	5	5	30
Cuzco	93	—	7	—	23
Arequipeño	100	—	—	—	—
San Geronimo Huancavelicano	50	26	8	16	29
Perla	—	100	—	—	—
Marañon	95	5	—	—	25
Cuzco Gigante	64	33	3	—	25
Aleman	100	—	—	—	—
Chuncho	50	—	50	—	—
Arizona	—	44	56	—	12
Morocho Cajabambino	—	100	—	—	—
Sarco	100	—	—	—	—
Perlilla	20	20	60	—	—

TABLE 10A. Frequencies of Ears with Indicated Kernel Texture.

Races	*Flint*	*Floury*	*Semi-Flint*	*Sugary*	*Segr. Flint & Floury*	*Segr. Sugary*
			Percent			
Confite Morocho	100	—	—	—	—	—
Confite Puntiagudo	87	9	—	—	2	2
Kculli	8	84	—	—	—	8
Confite Puneño	100	—	—	—	—	—
Huayleño	16	83	—	—	0.5	0.5
Chullpi	4	13	—	33	—	50
Granada	14	82	—	1	2	1
Paro	27	73	—	—	—	—
Huancavelicano	30	66	—	—	4	—
Rabo de Zorro	21	76	—	—	—	3
Piricinco	16	84	—	—	—	—
Ancashino	16	82	—	—	2	—
Shajatu	—	85	—	—	15	—
Sabanero	22	78	—	—	—	3
Uchuquilla	—	33	67	—	—	—
Cuzco Cristalino Amarillo	56	38	—	—	6	—
Cuzco	20	80	—	—	—	—
Arequipeño	—	100	—	—	—	—
San Geronimo Huancavelicano	25	71	—	—	2	2
Perla	50	50	—	—	—	—
Marañon	10	90	—	—	—	—
Cuzco Gigante	25	70	1.2	1.3	2.5	—
Aleman	—	—	100	—	—	—
Chuncho	—	—	100	—	—	—
Arizona	67	33	—	—	—	—
Morocho Cajabambino	50	—	—	—	50	—
Sarco	—	100	—	—	—	—
Perlilla	60	20	—	—	—	20

TABLE 11A. Distribution of Kernel Imbrication Scores.

	Low		*Scores*		*High*
Races	*0*	*0.5*	*1*	*1.5–2*	*2.5–3*
			Percent		
Confite Morocho	86	6	6	—	—
Confite Puntiagudo	37	15	23	20	5
Kculli	70	2	24	4	—
Confite Puneño	89	5.5	5.5	—	—
Huayleño	77	10	9	4	—
Chullpi	82	9	9	—	—
Granada	67	10	15	8	—
Paro	49	30	9	12	—
Morocho	87	3	7	3	—
Huancavelicano	75	11	14	—	—
Rabo de Zorro	59	19	6	16	—
Piricinco	100	—	—	—	—
Ancashino	50	14	23	13	1
Shajatu	75	11	7	7	—
Sabanero	100	—	—	—	—
Uchuquilla	100	—	—	—	—
Cuzco Cristalino	—	—	—	—	—
Amarillo	91	5	4	—	—
Cuzco	89	9	2	—	—
Arequipeño	86	—	14	—	—
San Geronimo Huancavelicano	96	4	—	—	—
Perla	100	—	—	—	—
Marañon	75	25	—	—	—
Cuzco Gigante	95	5	—	—	—
Aleman	100	—	—	—	—
Chuncho	50	25	25	—	—
Arizona	37	13	25	25	—
Morocho Cajabambino	100	—	—	—	—
Sarco	60	—	40	—	—
Perlilla	60	40	—	—	—

TABLE 12A. Chronology of Cultural Periods in Peru Simplified from Willey.

Epoch and Date	*Coast*			*Sierra*		
	North	*Central*	*South*	*North*	*Central*	*South*
1,500						
Post Classic	Inca Chimu	Inca Chancay	Inca Late Inca	Inca	Inca	Inca
1,000	Coastal Tiahuanaco	Late Ancon Middle Ancon Coast Tiahuanaco	Middle Inca Ica Epigonal Pacheco	Willkawain	Huari	Decadent Tiahuanaco
800						
500	Mochica		Huaca de Loro Late Nazca			
Classic	Gallinazo	Maranga	Middle Nazca Early Nazca	Recuay B	Proto Huari	Classic Tiahuanaco
A.D.						
B.C.						
Formative	Gallinazo Salinar Cupisnique	Maranga Playa Grande Baños de Boza Early Ancon Supe	Proto Nazca Late Paracas Early Paracas	Recuay A Chavin de Huantar	Qasawirka	Early Tiahuanaco Pucara Chanapata-Chiripa
1,000						
Incipient Farming	Early Guañape Huaca Prieta		Lomas			
2,500						
Early Hunting Gathering	San Pedro de Chicama		Otuma San Nicolas		Huancayo	Ayanipitan Viscachami
10,000						

List of Collections Selected for Study as Representing Each Race.

Races	*Collections**
Alazan	*Lib. 21, Lib. 26, Lib. 28, Lib. 34, Lib. 36, Lbque. 18,* Lbque. 16.
Aleman	*Hco. 38,* Hco. 56.
Ancashino	*Anc. 58, Anc. 67, Anc. 102, Anc. 153, Anc. 179,* Anc. 84, Anc. 178, Anc. 186, Anc. 198, Anc. 205, Anc. 238.
Arequipeño	Areq. 1, Areq. 22, Areq. 37, Areq. 32, Areq. 44.
Arizona	*Aya. 11, Aya. 41, Lib. 2, Lib. 16, Lbque. 12.*
Chancayano	Blanco: *Lim. 45,* Lim. 24; Pintado: *Lim. 44, Lim. 46.*
Chaparreño	*Areq. 34.*
Chimlos	*Cuz. 108,* Hco. 26.
Chullpi	*Aya. 32, Cuz. 57, Cuz. 99, Hvca. 42, Hvca. 156,* Apuc. 60, Apuc. 86, Aya. 19, Hvca. 69, Hvca. 86, Hvca. 118.
Chuncho	*Cuz. 110, Cuz. 112, Cuz. 122, Hco. 10, Hco. 63,* Cuz. 140, Cuz. 23, Hco. 61, Hco 76.
Confite Morocho	*Aya. 4, Aya. 20, Aya. 38,* Hvca. 136, Hvca. 48.
Confite Pueneño	Apuc. 56, Pun. 1, Pun. 2, Pun. 3, Pun. 4, Pun. 5, Pun. 6, Pun. 20, Pun. 21.
Confite Puntiagudo	*Caj. 9, Caj. 27, Cuz. 13, Cuz. 31, Cuz. 83, Cuz. 152, Hvca. 147, Jun. 68, Jun. 82, Anc. 250, Lib. 38,* Apuc. 54, Apuc. 75, Caj. 36, Caj. 53, Cuz. 42, Cuz. 43, Cuz. 127, Cuz. 141, Hvca. 68, Jun. 3, Jun. 66.
Coruca	Areq. 45, Tac. 1, Tac. 2, Tac. 6.
Cuzco	*Anc. 191, Caj. 61, Jun. 33, Jun. 35,* Jun 39, Anc. 77, Anc. 212, Anc. 251, Jun. 40, Lim. 11.
Cuzco O. Amarillo	*Cuz. 6, Cuz. 9, Cuz. 52, Cuz. 53, Cuz. 56, Cuz. 63, Cuz. 92,* Apuc. 23, Apuc. 48, Cuz. 34, Cuz. 40, Cuz. 58, Cuz. 60, Cuz. 74, Hvca. 6, Hvca. 34, Jun. 31.
Cuzco Gigante	*Apuc. 91, Caj. 17, Cuz. 77,* Caj. 16, Cuz. 2, Cuz. 87, Cuz. 89.
Enano	M. de Dios. 3.
Granada	*Anc. 57, Jun. 49, Pun. 25,* Anc. 56, Hvca. 5, Hvca. 83, Hvca. 91, Hvca. 102, Jun. 41, Jun. 55, Jun. 72, Jun. 73, Jun. 75, Pun. 25, Pun. 28, Anc. 12, Anc. 47, Pun. 32.
Huaychano	*Lim. 3, Lim. 10, Lim. 14, Lim. 43,* Tau. 5.
Huachano	*Anc. 180, Anc. 181, Anc. 183,* Anc. 51, Anc. 55, Anc. 90, Anc. 94, Anc. 129, Anc. 180, Anc. 182, Anc. 222, Anc. 224, Anc. 234, Anc. 302, Hvca. 4, Hvca. 21, Hvca. 134.
Huancavelicano	*Cuz. 88, Hvca. 53, Hvca. 112,* Apuc. 63, Aya. 17, Cuz. 38, Cuz. 47, Cuz. 145, Hvca. 90, Hvca. 94, Hvca. 110, Hvca. 111, Hvca. 113, Hvca. 120, Hvca. 125, Hvca. 127, Hvca. 96, Hvca. 100, Hvca. 104, Hvca. 107.
Jora	*Anc. 9.*
Kculli	*Cuz. 75, Hvca. 137, Jun. 58, Jun. 65,* Caj. 24, Cuz. 17, Cuz. 37, Cuz. 128, Cuz. 148, Hvca. 121.

(*Continued on following page.*)

List of Collections Selected for Study as Representing Each Race. (Cont'd.)

Races	*Collections**
Mochero	*Lbque. 5, Lbque. 7, Lbque. 14, Lbque. 15, Lbque. 17, Lbque. 6,* Piu. 1, Tac. 1.
Maranon	*Anc. 327, Anc. 334, Anc. 336, Lib. 47, Lib. 68, Lib. 48, Lib. 50, Lib. 55, Lib. 56, Lib. 63, Lib. 66, Lib. 67, Lib. 70,* Lib. 60, Anc. 319.
Morado Canteno	Lim. 34.
Morocho	*Amz. 7, Amz. 17, Anc. 173, Lib. 40, Lib. 42, Apuc. 29, Apuc. 39, Apuc. 67, Aya. 22,* Amz. 25, Amz. 27, Amz. 28, Amz. 34, Amz. 37, Anc. 214, Anc. 320, Hco. 62, Jun. 29, Desc. 6, Apuc. 26.
Morocho Cajabambino	*Amz. 3, Amz. 9, Caj. 19, Lib. 62, Amz. 16.* Amz. 16.
Pagaladroga	Lib. 24, Lib. 7, Piu. 2.
Pardo	*Lim. 19.*
Paro	Apuc. 25, Apuc. 40, Apuc. 96, Apuc. 97, Chz. 76, Cuz. 132.
Perla	*Anc. 20, Anc. 21, Anc. 23, Anc. 24, Lib. 4, Lib. 44, Lim. 2, Lim. 4, Lim. 8, Lim. 12, Lim. 13, Lim. 48, Lim. 50, Lim. 52, Lim. 53, Lim. 56,* Anc. 1, Anc. 8, Hco. 86a, Lib. 20, Lim. 18, Lim. 22, Lim. 47.
Perilla	*Hco. 91.*
Piricinco	*Lor. 8, Lor. 9, Lor. 11, SMtn. 1, SMtn. 7, SMtn. 8, SMtn. 9, SMtn. 10. SMtn. 19, SMtn. 20.* M. de Dios. 8, SMtn. 2.
Pisccorunto	Apuc. 10, Apuc. 13, Desc. 4.
Rienda	*Lib. 76.*
Rabo de Zorro	*Anc. 203,* Anc. 235.
Shajatu	Anc. 117, *Anc. 120, Anc. 152,* Anc. 126, Anc. 128, Anc. 150.
Sabanero	*Caj. 52, Caj. 65.*
Sarco	Anc. 184, Anc. 85, Anc. 81.
San Geronimo Huancavelicano	*Hvca. 17, Hvca. 144, Hvca. 33, Hvca. 52,* Anc. 73, Anc. 99, Anc. 122, Hvca. 8, Hvca. 28, Hvca. 37, Hvca. 50, Hvca. 52, Hvca. 145, Jun. 46, Jun. 71.
Uchuquilla	*Pun. 15,* Pun. 16, *Pun. 18,* Pun. 12, Pun. 9, Pun. 14.

* Collections in italics are true-breeding typical of the race.

NATIONAL ACADEMY OF SCIENCES— NATIONAL RESEARCH COUNCIL

The National Academy of Sciences–National Research Council is a private, nonprofit organization of scientists, dedicated to the furtherance of science and to its use for the general welfare.

The Academy itself was established in 1863 under a Congressional charter signed by President Lincoln. Empowered to provide for all activities appropriate to academies of science, it was also required by its charter to act as an adviser to the Federal Government in scientific matters. This provision accounts for the close ties that have always existed between the Academy and the Government, although the Academy is not a governmental agency.

The National Research Council was established by the Academy in 1916, at the request of President Wilson, to enable scientists generally to associate their efforts with those of the limited membership of the Academy in service to the nation, to society, and to science at home and abroad. Members of the National Research Council receive their appointments from the President of the Academy. They include representatives nominated by the major scientific and technical societies, representatives of the Federal Government, and a number of members-at-large.

Today the over-all organization has come to be known as the Academy–Research Council and several thousand scientists and engineers take part in its activities through membership on its various boards and committees.

Receiving funds from both public and private sources, by contribution, grant, or contract, the Academy and its Research Council thus work to stimulate research and its applications, to survey the broad possibilities of science, to promote effective utilization of the scientific and technical resources of the country, to serve the Government, and to further the general interests of science.