RACES OF MAIZE IN MEXICO

THEIR ORIGIN, CHARACTERISTICS AND DISTRIBUTION

E. J. Wellhausen, L. M. Roberts and E. Hernandez X.
in collaboration with
Paul C. Mangelsdorf

THE BUSSEY INSTITUTION
of
HARVARD UNIVERSITY
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An English edition of RAZAS DE MAIZ EN MEXICO by the same authors. First published in Mexico, April, 1951, as Folleto Tecnico No. 5, Oficina de Estudios Especiales, Secretaria de Agricultura y Ganaderia, Mexico, D. F.

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FOREWORD

When, in 1943, the Rockefeller Foundation, in cooperation with the Mexican Ministry of Agriculture began a program of practical maize improvement it became evident almost at once that a survey of the native maize varieties was needed to serve as an inventory of the material available to the plant breeders. A systematic program of collection, originally wholly utilitarian in purpose, was begun. Varieties were assembled from all parts of Mexico and, in controlled experiments, were compared for productiveness, disease resistance and other characteristics of agricultural importance. As the collections grew and the extraordinary diversity of maize in Mexico began to be revealed, the need of a taxonomic classification which would make some semblance of order out of the bewildering multiplicity of varieties became apparent. Botanical, genetic and cytological studies to supplement the agronomic investigations were begun and, to make the collections as nearly complete as possible, special efforts were made to obtain little-known varieties, of doubtful agronomic importance, from remote localities. Gradually it became possible to discern relationships between varieties and to group these into more or less well-defined natural races. And since relationships are implicit in any natural system of classification, a definite attempt has been made to determine the origins and relationships of the recognized races. What had begun as a strictly utilitarian venture of limited scope has evolved into a study of the evolution, in one geographical region, of America's most important cultivated plant. One result has been that the corn breeders of Mexico now have a far more useful inventory than they originally sought, of the breeding material available in their country and can now approach new breeding problems with some degree of confidence in their choice of stocks.

The conclusions on origins and relationships presented in this monograph are not to be regarded as final. They represent no more than the best interpretations which the authors were able to make from their observations and data. Some have substantial evidence in their support and have already proved useful; others are necessarily still speculative and will require modification as new evidence from the maize of other countries is brought to bear upon the problem. Indeed one of the most useful purposes which this monograph could serve is to focus attention on the need for similar studies in other parts of America.

Maize is the basic food plant in most of the Americas and its diversity, the product of thousands of years of evolution under domestication, is one of the great natural resources of this hemisphere. To lose any part of that diversity is not only to restrict the opportunities for further improvement but also to increase the difficulties of coping with future climatic changes or with new diseases or insect pests. The modern corn breeder, therefore, has a responsibility not only to improve the maize in the country in which he works but also to recognize, to describe and to preserve for future use, the varieties and races which his own improved productions tend to replace and in some cases to extinguish.

A Spanish edition of this monograph has been published earlier, under the auspices of the Mexican Ministry of Agriculture in cooperation with the Rockefeller Foundation. The two editions are alike in all essential details and in their conclusions and differ only slightly in the arrangement of descriptive material. The Bussey Institution of Harvard University, which has been concerned with studies of maize for almost half a century, has undertaken the publication of this English edition for two reasons: a member of its staff has participated in the research which it reports and the data and conclusions which it contains promise to be of some interest to English-speaking botanists, geneticists and plant breeders and of potential importance to future agricultural improvement in the United States.

PAUL C. MANGELSDORF

ACKNOWLEDGEMENTS

This study is the product of the cooperative efforts of many individuals. Credit is especially due to the following Ingenieros Agrónomos of Mexico for help in collecting varieties and in collecting and summarizing the data on which this study is based: Ing. Reynaldo Luis Pineda, Ing. Raúl Miravete A., Ing. Gilberto Palacios de la Rosa, Ing. Atanasio Cuevas R., Ing. Raúl Palacios A., Ing. Miguel Monroy R., Ing. Félix Agramont C., Ing. Amador Terán T., Ing. Neftalí Bautista R., Ing. Humberto Rosado E., Ing. Pedro Montellano C., Ing. Rogelio Espinosa Ochoa, Ing. Carlos Aguirre S., Ing. José Martínez Beltrán, Ing. Humberto Cárdenas, Ing. Carlos Vargas S., Ing. Alberto San Vicente G., e Ing. Francisco López Cortez.

Special credit is also due to Dr. Earlene Atchison who prepared the cytological material and made the chromosome knob counts of the different races; to Mr. James Pate for his help in obtaining and summarizing data on the morphological characters of the plants and external characters of the ears; to Dr. Lee Lenz for help with the condensation indices of the tassels; to Ing. Atanasio Cuevas R. for the data on the internode patterns; to Dr. C. C. Gilly for the use of his map identifying the geographical regions of Mexico; and to Dr. Isabel Kelly for her help in the collection of corn.

In connection with the preparation of the manuscript the authors are indebted to Ing. Pedro Montellano C. for assistance in making the ear cross-section diagrams; to Mrs. Vivian Wellhausen for making the distribution maps, the pedigree diagrams and the charts for the internode patterns; to Mrs. Betty Roberts for typing the manuscript; to Ing. Prof. José Luis de la Loma for his assistance in translation and preparation of the Spanish version; and to Arthur Smith and Byron MacLellan for invaluable assistance in connection with the photography.

The authors are particularly grateful to Dr. Dorothy Parker for her many hours of very exacting work in checking the script, the arrangement of the numerous tables, illustrations, and charts, and the final editing and proofreading of the manuscript. Her willing service and cooperation in this very important final task is greatly appreciated.

Finally the authors are greatly indebted to Dr. J. George Harrar, Director of the Rockefeller Foundation Agricultural Program in Mexico, and to Ing. Edmundo Taboada, Director of the Instituto de Investigaciones Agrícolas, S.A.G., who, by their continuous support, made this work possible.

RACES OF MAIZE IN MEXICO

Their Origin, Characteristics and Distribution

E. J. Wellhausen, L. M. Roberts and E. Hernandez X.[1]
in collaboration with
Paul C. Mangelsdorf [2]

INTRODUCTION

For more than seven years beginning in the fall of 1943, the Rockefeller Foundation in connection with its Agricultural Program in Mexico, represented by the Office of Special Studies of the Mexican Ministry of Agriculture, has systematically collected varieties of maize from all parts of the Republic. The collection now includes more than 2,000 entries and, although certainly not complete, is probably the most extensive collection of maize which has ever been made in a single country. Exploration for new types has already reached a point of diminishing returns and it is doubtful whether many distinct races not already included in the present collection will be encountered in the future. At least the races which have entered into the composition of the important agricultural types of Mexico are now largely accounted for. Primitive races grown only in isolated localities at high altitudes will undoubtedly continue to be discovered with additional exploration.

The maize varieties in this collection have been intensively studied not only from the standpoint of their external morphological characteristics and their internal cytological features but also with respect to physiological characteristics such as earliness, resistance and susceptibility to disease, and yield. These studies have now reached a point where it is possible to discern natural relationships between varieties and to group them according to these relationships into races. It is possible, moreover, to draw at

[1] Geneticist, Associate Geneticist of the Rockefeller Foundation and Agrónómo, Oficina de Estudios Especiales, S.A.G.

[2] Professor of Botany, Bussey Institution, Harvard University and Consultant for Agriculture, Rockefeller Foundation.

least tentative conclusions regarding the origin of the different races. It is now practicable for the first time to make a natural classification of the maize of Mexico.

The maize of Mexico is of extraordinary interest from several standpoints. In no other country in America has maize become so overwhelmingly important in the social and economic life of the people as it is in Mexico. Whether maize had its origin in Mexico is still a debatable question, but that maize is a cultivated plant of considerable antiquity in Mexico is certain. In no other country, perhaps, is the total spectrum of variation in maize so great as it is in Mexico. True, there is greater variability in certain characteristics such as kernel size in the maize of Peru and Bolivia. And in one department of Guatemala one finds more variability in a small area than is found in areas of comparable size elsewhere (Mangelsdorf and Cameron, 1942). But considering the country as a whole it is probably safe to say that Mexico surpasses any other single country in the wealth of diversity of its races and varieties of maize.

At least four factors involved in the tremendous diversity of maize in Mexico are recognizable: (1) primitive races, which in such countries as Peru are found largely as archaeological remains, are encountered in Mexico as living varieties; (2) sometime during the history of maize cultivation in Mexico there has been an influx of exotic varieties from countries to the South; (3) teosinte has hybridized with maize in Mexico and in adjacent regions of Guatemala and has introduced new characteristics and new diversity into the maize of both countries; (4) the geography of Mexico, involving as it does several kinds of isolating factors, is conducive to rapid differentiation.

The maize of Mexico is also of particular interest because of the role which it has played in the development of the modern, highly productive varieties of the Americas, especially those of the Corn Belt of the United States. Hence, the classification of the maize of Mexico is of interest not only to students of cultivated plants in general and of maize in particular, but may also become of importance to plant breeders concerned with the improvement of this plant. To the corn breeder a valid classification is of more than academic interest; to him it represents an inventory of the morphological and physiological assets and liabilities at his command in shaping the characteristics of this unique and important American cereal.

HISTORY OF MAIZE CLASSIFICATION

The classification of cultivated plants has not kept pace with the classification of natural species and the reasons are not far to seek. The principal one lies in the kind of variation in the two categories of plants. In nature variation is usually discontinuous and natural species have usually become separated by well-defined morphological gaps. In genera where this has not yet occurred the taxonomist is likely to regard the species as not "good". In cultivated plants, on the other hand, discontinuous variation is rare and is more often the exception than the rule. Frequently there are no sharp lines of demarcation between the varieties or races which comprise a cultivated species or genus. This is especially true when the variation is entirely intraspecific. It is almost inevitably true when, in addition, the species is one in which natural cross-fertilization, accompanied by a continuous interchange of genes between populations, is the rule.

Since maize not only belongs to a single species but is also largely cross-fertilized, it offers more than the ordinary number of difficulties to the taxonomist. Hence, it is not surprising that the classification of maize, in spite of its importance, should have been so long neglected. Taxonomists who shun cultivated plants as not botanically important may actually be avoiding difficult problems not easily solved by traditional taxonomic methods. The variation in cultivated plants is frequently so bewildering that additional techniques including those of the geneticist, the cytologist and the agronomist are needed to bring a semblance of order out of apparent chaos.

The earliest comprehensive treatment of the problem of maize classification is that of E. Lewis Sturtevant who, a half century ago (1899), published a monograph entitled "Varieties of Corn". Sturtevant catalogued the variability of maize then known to him into six main groups, five of which were based upon the composition of the endosperm of the kernel. This classification has been used almost without modification for the past fifty years, and for almost the same length of time interest in advancing the classification of maize has remained dormant.

In recent years, partly as the result of an accumulated body of knowledge on the genetics and cytology of maize, partly as an outgrowth of new hypotheses concerning the origin of maize and its relatives, there has been a revival of interest in the classification of maize. Especially significant in this connection has been the work of Anderson and Cutler who, in a series of papers published jointly and separately, have brought to bear upon the problem new evidence from botany, genetics, and archaeology. In their first paper on maize classification (1942) these writers pointed out that Sturtevant's classification, while useful, is largely artificial since it is based almost entirely upon characteristics of the endosperm, some of which are now known to be dependent for their expression upon a single locus on a single chromosome. A natural classification, according to Anderson and Cutler, is one which is based upon the entire genetic constitution and which integrates the maximum number of genetic facts. As a mere cataloguing device a natural classification may be no more useful than an artificial one, but as a means of showing relationships and tracing origins it can be infinitely more valuable. Anderson and Cutler sought characteristics which would be more useful in reflecting the entire genotype than did Sturtevant's endosperm characteristics. They have made an especially important contribution in showing that the maize tassel, which in many respects is the homolog of the ear, is valuable in studying and classifying the variation in maize. They have also discovered new characteristics in the ear which have proved to be useful in classification.

More recently Mangelsdorf and Smith (1949) in making a study of prehistoric cobs have described a number of internal characteristics of the cob which promise to be of importance in the classification of maize and which have been employed in the present study.

The classification of maize presented in this paper has made use not only of the morphological characteristics of the ear, the tassel and the plant, but also of genetic, cytological, physiological and agronomic characteristics. Special consideration has also been given to geographical distribution which is of great importance in recognizing races. It is only by analyzing and integrating the evidence from these various sources, we believe, that a valid and natural classification of maize can be made.

PREVIOUS STUDIES OF MEXICAN MAIZE

Although no comprehensive study of the maize of Mexico has previously been made, many of the races which exist in Mexico and which are treated in this monograph have been mentioned, described or depicted in earlier publications. Of particular importance is the work of Chávez done in 1913 which later appeared, with only slight changes and without explanation, under the authorship of Erdozain (1914). In the photographs in this publication are recognizable twelve of the twenty-five principal races to be described in the present paper. Other Mexican works in which one or more races of maize are referred to are those of Sahagún (1529–1590), de la Rosa (1846), López y Parra (1908 a, b), Khankhoje (1930), Montelongo (1939), Pérez Toro (1942), Cuevas Ríos (1947), Souza Novelo (1948) and Bautista R. (1949).

The Russian botanist, Kuleshov, whose principal interest was maize, made with his colleagues a special study of the maize of the Mexican Plateau. However, several of the races of western and southern Mexico were also encountered and are mentioned in two papers by Kuleshov (1929, 1930).

The most important American work on the subject of maize in Mexico is that of Anderson (1946a) which describes or refers to ten of the twenty-five races now recognized and mentions several additional types which are treated in the present classification as sub-races. Other papers which include descriptions or references to one or more races will be referred to specifically in connection with the detailed descriptions of the races.

ANTIQUITY OF MAIZE IN MEXICO

Many botanists in the past have thought that maize had its origin in Mexico. Their opinions were largely based upon the fact that teosinte, the closest relative of maize and considered by many to be the progenitor of maize, is common in Mexico. The possibility that maize has stemmed directly from teosinte is now almost precluded as the result of recent evidence from prehistoric maize discovered in New Mexico. This material described by Mangelsdorf and Smith (1949) suggests that primitive maize was a pod corn and not a teosinte derivative. The question of where this primitive pod corn arose is not answered by the new evidence. Maize may have been indigenous to Mexico, to one or more of the countries of Central America, or to South America. But wherever maize may have had its origin as a wild plant, there can be no doubt that maize has had a long history in Mexico. Evidence for this is found in prehistoric carvings and ceramics, in the ancient codices, in impressions of ears of maize in lava from volcanoes long extinct, in actual remains of prehistoric maize and in the circumstantial evidence concerned with ancient maize of other regions.

Maize is frequently represented in the ancient stone carvings and the pottery of prehistoric Mexico. Some of these representations are highly stylized and tell little about the nature of the maize itself. Others are beautifully realistic and are almost equal to modern photographs in revealing the characteristics of the maize which they depict. A complete study of these prehistoric stone and clay replicas in the museums of the world would entail a special program of research beyond the scope of this paper. Several specimens of prehistoric carving and pottery are reproduced in Figures 1 and 2 and in Plate I. Especially interesting is the Zapotec funerary urn illustrated in Figure 1, which is ornamented with ears of a type of dent corn, and therefore proves that this kind of maize was already in existence in prehistoric times. The Zapotec Maize Goddess, Centiocihuatl, shown in Figure 2, has a headdress ornamented by ears which were made by means of moulds of actual ears. These ears are very similar in size, shape, number of rows and kernel type to the ears of a race that presently exists in Mexico, which will be described in detail later in this paper as the primitive race Nal-Tel. Archaeological evidence dates this Zapotec idol at approximately 600 to 800 A.D.

Maize is repeatedly illustrated in the prehistoric codices, and a study and an interpretation of some of these illustrations has recently been made by Meade (1948). In the codices, as in the prehistoric pottery, much of the maize is highly stylized (Fig. 3) and little or nothing with respect to its botanical characteristics is revealed. An exception to this is the maize illustrated in the Yanhuitlán Codex which, as has been pointed out by Anderson and Finan (1945), was distinguished by broad, more or less bent leaves and by short, many-rowed ears.

FIG. 1. Dent corn on a prehistoric Zapotec funerary urn (courtesy National Museum, Washington, D. C.)

Impressions of ears of maize in prehistoric lava have been found in several localities in Mexico. The most interesting specimen of this kind is the one on display in the local museum in Morelia (Fig. 4) which has upon its various surfaces a number of impressions of different ears. One of these is particularly well-formed and shows a small, slender, more or less cylindrical ear with small kernels, not very different from the Chapalote or Nal-Tel maize of today. Other impressions in the same block are of

FIG. 2. The ears ornamenting the headdress of the Zapotec maize Goddess, Centiocihuatl, are almost identical to the ears of a race that exists in Mexico at the present time, Nal-Tel. This idol was found in the excavation of Monte Albán, Oaxaca and is estimated by archaeologists to date back to between 600–800 A.D. (courtesy of the National Museum, Mexico, D. F.)

ears of a quite different type and definitely resemble Cónico, the most common race in the Mexican Plateau at the present time.

Since there has been no volcanic activity in the Valley of Morelia in historic times nor any traditions of active volcanoes in the immediate pre-Conquest period, it is probable that the impres-

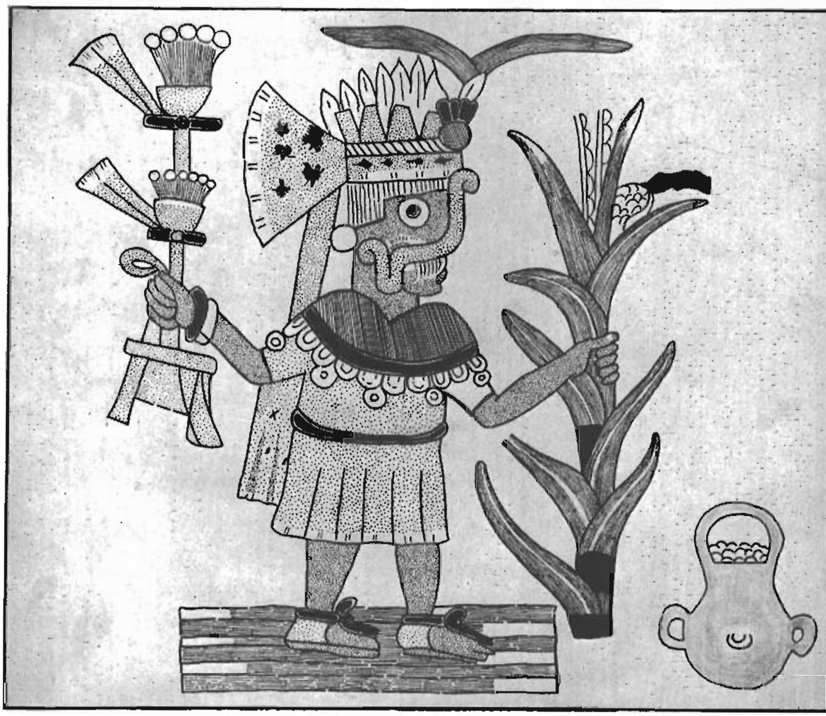


FIG. 3. Tlaloc-Aztec God of rain with stalk of maize in one hand and jar of maize at lower right. (From "The book of life of the ancient Mexicans," by Zelia Nuttall.)

sions in the Morelia lava are quite ancient. They serve to show that a type of maize not greatly different from races still known today existed centuries ago. They show further that maize in Mexico in ancient times was, as it is today, extremely variable.

There are few actual remains of prehistoric maize in Mexico. Anderson (1946a) mentions the maize uncovered by Gamio in the excavation at Teotihuacan and describes it as being quite similar to the present-day pop corn and pop-dents (Cónicos) of the region.

Finally, the most convincing evidence of the antiquity of maize comes not from Mexico itself but from an adjoining region, the southwestern United States. There in an abandoned cave known as Bat Cave located on the shores of an ancient lake now almost

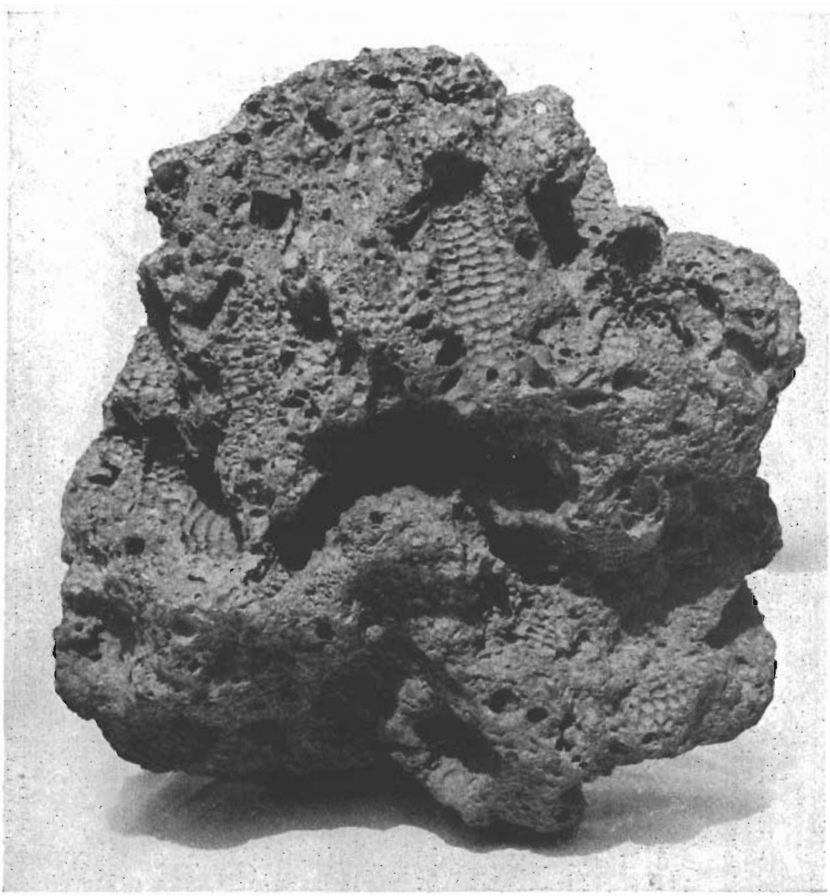


FIG. 4. Impressions of maize ears in a prehistoric block of lava from the valley of Morelia, Michoacán. (Photo taken from the original in the Museum of Morelia.)

extinct, in New Mexico, has recently been found a cultural deposit which is conservatively dated on geological evidence at 2000 B.C. (Recent determinations of radiocarbon by Libby and his associates indicate that the deposit may be much older.) In this deposit were found cobs of prehistoric maize which have been described by

Mangelsdorf and Smith (1949) and which not only reveal the nature of primitive maize but which also provide for the first time direct evidence of an evolutionary sequence. The earliest maize found in Bat Cave had small slender ears, not completely enclosed by the husks, and was both a pod corn and a pop corn. Since maize could scarcely have existed as a wild plant in the region in which Bat Cave is located, it is assumed that it must have been introduced there as a cultivated plant from elsewhere, probably from Mexico. In this case, maize must have been grown as a cultivated plant in Mexico at least by 2000 B.C. and perhaps much earlier. The present-day races of maize in Mexico are, therefore, the product of 4000 years or more of evolution under domestication.

The prehistoric maize from Bat Cave in New Mexico not only proves that primitive maize was a kind of pod corn, its kernels being partly or completely enclosed in glumes, but it also proves beyond a reasonable doubt that maize did not originate from teosinte. At the same time, however, it indicates that teosinte has played an important role in the later evolution of maize. The earliest maize from Bat Cave is uniformly pod corn or weak pod corn. Later, about midway in the evolutionary sequence, ears exhibiting convincing evidence of teosinte introgression make their appearance and eventually become the predominating type. Since there is no teosinte in New Mexico today, and no evidence that it has ever occurred there in the past, the characters from teosinte, like the primitive maize itself, must have been introduced into New Mexico from elsewhere, probably from Mexico. This suggests that the introgression of teosinte into maize had already occurred in Mexico before it became evident in New Mexico. The role of teosinte in the evolution of maize must now be considered not as an interesting hypothesis but as an established fact.

HOW RACES OF MAIZE HAVE ARISEN

As a result of the facts revealed by the evolutionary sequence in the Bat Cave maize, combined with an intensive study of the maize varieties of Mexico, it is now possible to see how races of maize have come into existence. Beginning with the primitive pod corn which undoubtedly became widely distributed several thousand years ago, distinct varieties of maize developed in different regions. The principal factors involved in the early evolution of maize were the relatively frequent mutations and a partial release from the pressure of natural selection through the intervention of man. Since the ears and kernels of the original wild corn were undoubtedly already quite small, new variations were likely to be in the direction of increased rather than decreased size. The consequence has been that the maize ear has now for 4,000 years or more been gradually increasing in size.

Superimposed upon this evolutionary trend with respect to size there has been a definite trend toward increased variation and enhanced productiveness resulting from hybridization. Some of the distinct races which evolved in different regions of America were sooner or later brought together through the peregrinations of man. Hybridization occurred and undoubtedly in ancient times, as it does today, resulted in hybrid vigor. Hybrid vigor is usually thought of as the increased vigor which manifests itself in the first generation following hybridization and it is this kind of hybrid vigor which is exploited in the production of modern hybrid corn. Less generally recognized is the fact that a certain fraction of the hybrid vigor persists into later generations. This phenomenon can be described by a simple formula developed by Wright (1922), who concluded that in later generations of a hybrid there is a retrogression in vigor toward the level of the parents, and that this retrogression is equal to $1/n$ of the difference between the average production of the parents and the production of the hybrid where n is the number of inbred strains which enter into the ancestry of a hybrid.

Although Wright's formula was developed to account for the decrease in vigor which occurs in later generations of a hybrid of inbred strains, it seems to apply to hybrid vigor resulting from the crossing of more or less heterogeneous cross-fertilized varieties. In theory, then, if two varieties whose normal yield is called 100 percent are crossed to produce a hybrid whose yield is 120 percent, then the second generation, the F_2, should yield 110 percent. Furthermore, a genetic equilibrium will have been reached in F_2 and, in a system of random mating, all subsequent generations will continue to be about 10 percent more productive than the parental stocks. Data are available from the experiments of Kiesselbach (1930), Neal (1935), Richey et al (1934), Sprague and Jenkins (1943), and Wellhausen and Roberts (1949) which show that the effects of hybrid vigor persist into advanced generations. Thus, maize under domestication is potentially a self-improving plant. Distinct, more or less homogeneous varieties or races evolve in the isolation of separated regions. Man brings these varieties or races together under conditions where cross-fertilization is inevitable, and a new hybrid race is born. Repeated cycles of this series of events inevitably lead to the development of more productive races even without direct or conscious selection by man.

Superimposed upon these two evolutionary mechanisms, mutation and racial hybridization, at least in Mexico and Central America, is the introgression of genes from teosinte into maize. The importance of this third evolutionary factor is difficult to overemphasize, for, as will be shown later, all of the more productive varieties of maize in Mexico show evidence of teosinte introgression. If Mangelsdorf and Reeves (1939) are correct in their hypothesis that teosinte is a hybrid of maize and Tripsacum, then the genes involved in the introgression are actually Tripsacum genes. For our immediate purposes, however, the distinction is not especially important and we shall refer to the introgression as coming from teosinte which in most instances is its immediate source.

There is no doubt (at least on the part of those who have studied the problem intensively) that there is in Mexico a constant and reciprocal introgression of maize and teosinte. This is easily seen in the maize fields in various parts of Mexico and is especially well illustrated in the vicinity of Chalco, a village 34 kilometers southeast of Mexico City. In this region teosinte grows in profusion as a weed in the maize fields. Its flowering period overlaps the flowering period of maize, and natural hybridization between the two species is constantly occurring. Evidence for this is found in the first-generation hybrids which make up a small but constant fraction of the plants in the field. These in turn are constantly backcrossing with the two parental forms so that there is a repeated introgression of maize into teosinte and of teosinte into maize. As a consequence the teosinte in the vicinity of Chalco has acquired a number of distinctive traits characteristic of the maize of the region including strongly pigmented and pubescent leaf sheaths. Even yellow endosperm, usually confined to maize, is sometimes found in the teosinte kernels (Mangelsdorf, 1947) and colored aleurone also occurs. The maize in the same region shows unmistakable evidence of teosinte introgression in a number of characteristics, particularly the induration of the rachis and glumes.

A similar situation exists in other parts of Mexico and Guatemala where teosinte either occurs as a weed in the corn fields or where it grows in profusion in uncultivated areas adjacent to the corn fields. In this connection Lumholtz (1902) reports that in western Mexico teosinte is sometimes actually planted in the same field with maize for the purpose of "improving" the latter.

There are barriers to natural crossing between teosinte and maize which prevent a completely free interchange of genes between them, nevertheless there is no doubt that an introgression of teosinte into maize is occurring at the present time in Mexico and there is little reason to doubt that it has occurred in the past for as long a period and as often as the two species have been in contact.

CHARACTERS USED IN CLASSIFICATION

The characters used in classifying the maize of Mexico comprise four principal categories: (1) vegetative characters of the plant; (2) characters of the tassel; (3) characters of the ear, both external and internal; and (4) physiological, genetic and cytological characters.

In comparing the races of maize with respect to these categories of characters, only those collections which appeared to be most typical of the race were studied in detail. A list of the collections studied is given in Table 18 (Appendix). The number of collections selected as being typical of a given race varied from one to twenty-four as is evident in Table 18 and as is shown in Column 2 of Table 13. The data in Tables 13–17 (Appendix) are averages based on the measurements made on these varying numbers of collections for each given race. These data, therefore, represent a highly selected rather than a random sample of the variation in each race. Such a procedure was followed since it appeared that a necessary first step in the classification of the maize of Mexico was to identify and describe the recognizable races. Selected collections to represent a race were used in much the same way that taxonomists use selected "type" specimens. This procedure has definite shortcomings but if these are recognized can also be useful. Once the basic racial elements are recognized then the variation within races as well as that resulting from recent mixing of races can be more easily understood and interpreted. These problems will be given attention as the study of the maize of Mexico is continued.

The characters employed in this classification and the methods by which they were studied are described below:

VEGETATIVE CHARACTERS OF THE PLANT

Vegetative characters of the plant are for the most part strongly influenced by environmental variation. It is a question which is more valid: to compare varieties and races in one environment, which for the majority is one to which they are unadapted, or to compare them as they grow in their own different environments. Perhaps a combination of data from the two sources would be desirable. Here we are concerned with data derived almost entirely from comparisons made under constant environmental conditions. The characters which have been thus studied (Table 13) are:

Adaptation to Altitude. While corn is found growing in Mexico from sea level to more than 3000 meters, each particular race is adapted to a relatively small fraction of this range in altitude. Some races are especially sensitive to changes in elevations while others show greater plasticity in their adaptation to ranges of altitude. Adaptation to altitude is undoubtedly dependent on many factors, some of which are not yet understood. One of the most important of these is temperature, which in a tropical country such as Mexico is directly related to altitude. Exact altitudes where most of the collections were made were recorded with the aid of an aneroid altimeter. For a small percentage of the collections, the elevations were taken from a topographical map prepared by the American Geographical Society of New York. The range of altitudes for each race treated in Table 13 is based on the elevations of the locations where samples representative of the race were collected.

Height of Plant. An estimate of the height of plant for each collection was obtained by measuring a mature plant selected as being typical in a plot containing approximately sixty plants. The measurement was made on the main stalk from the ground to the base of the tassel. Estimates thus made at Chapingo in 1946 and 1947 were averaged.

Total Number of Leaves per Plant. Actual counts were made of the total number of leaves on twenty plants of each collection at Chapingo in 1945. To insure comparable sampling, the first twenty normal plants in a plot were selected for counting.

Number of Leaves Above Ear. The number of leaves above the primary or upper ear were counted on the same plants used to determine the total number of leaves per plant.

Width of Leaf. Measured in centimeters on the leaf arising from the upper ear-bearing node at the mid-point of its length. The mean for each collection is based on twenty plants measured at Chapingo in 1945.

Length of Leaf. Data obtained from the same twenty leaves used to determine width of leaf. The leaves were measured from the ligule to the tip.

Venation Index. Following the method established by Mangelsdorf and Reeves (1939), the average number of veins counted at the mid-point in the length of the leaf from the upper ear-bearing node was divided by the average width. The counts and measurements were made on ten mature plants grown at Celaya, Guanajuato in 1948.

Internode Patterns. According to Anderson (1949) each kind of corn has its own characteristic pattern of internode elongation. We have found internode patterns (Plate VII) to be a useful tool in showing relationship between races. The pattern for a particular race was determined by measuring the length of each successive internode on each of five typical plants. The results were then averaged and expressed in a diagram showing the pattern of relative internode lengths with relation to ears and tassel. Numbers on the vertical scale in the diagrams represent lengths of each internode in centimeters. Numbers at the base of the diagram represent the order of the internodes from the base upwards. Tassels are represented by circles and ears by an ellipse.

CHARACTERS OF THE TASSEL

Anderson and Cutler (1942) regard the tassel as the most useful organ of the maize plant for purposes of classification and state that "The tassel of *Zea Mays* presents us with more easily measured characters than all the rest of the plant combined." We are not convinced that this is true. Nevertheless, the tassel is an extremely useful structure in classification and one which had been largely neglected until Anderson and Cutler focused attention on it. The characters of the tassel employed in this study (Table 14) are described below. Several of the characters of the tassel which Anderson (1944b) found to be closely correlated with characters of the ear were not used, since it seemed better to study the ear itself than to draw inferences regarding it from homologous structures in the tassel.

Tassel Length. The length was measured in centimeters from point of origin of the lowermost branch to the tip of the central spike. The average for each collection was derived from thirty tassels; twenty measured at Chapingo in 1945 and ten measured at Celaya in 1948.

Length of Peduncle. The distance was measured in centimeters from the upper node of the stalk to the lowermost branch in the tassel. The average for each collection is based on five plants.

Length of Branching Space of Tassel. The length along the central axis of the tassel on which branches occurred was measured in centimeters on ten plants in each collection at Celaya in 1948.

Percent Branching Space. The percentage derived by dividing the average length of that part of the central axis on which branches occurred by the total average length of the tassel.

Total Number of Tassel Branches. All branches, primary, secondary, and tertiary, were counted in the tassels on the main stalk of thirty plants, twenty counted at Chapingo in 1945 and ten at Celaya in 1948.

Percentage of Secondary Branches in Tassel. The total number of secondary branches in the tassel on the main stalk of ten plants of each collection was divided by the total number of branches in the same tassels. The data were taken at Celaya in 1948.

Percentage of Tertiary Branches in Tassel. Determined in the same manner and on the same tassels as described for percentage of secondary branches.

Condensation Index. The average condensation index of ten tassels from each collection was determined according to the technique described by Anderson (1944b). The index is computed by dividing the number of pairs of spikelets by the number of apparent nodes counted along the central portion of the lowermost primary branch in the tassel.

CHARACTERS OF THE EAR

Since the ear is the most highly specialized organ of the maize plant and is the structure which, more than any other, distinguishes *Zea Mays* from all other species of grasses, it is reasonable to suppose that the ear and not the tassel would offer more useful diagnostic characters than any other part of the plant. We believe that this is, indeed, the situation. In any case, it is obvious that the characters of the ear must be employed as fully as possible in any system of classification since the ear is frequently the only part available for collection and study. Especially is this true of archaeological remains of prehistoric corn. Consequently, we have devoted particular attention to characteristics of the ear, not only to gross external characteristics but also to internal characteristics.

EXTERNAL CHARACTERS

The external characters of the ear (Table 15) are, with two exceptions, a matter of simple measurement or counting. The way in which the data were obtained is described below.

Ear Length. Measurements in centimeters were made on twelve to fifteen ears from each collection. Upper ears from the main stalk were selected at random after discarding those that were obviously abnormal and unsound.

Mid-ear Diameter. The diameters of the same ears used to determine ear length were measured in centimeters with calipers at the mid-point of their length.

Row Number. Actual counts were made of the number of rows of grain on the same ears used for length and diameter determinations.

Shank Diameter. The diameter of the shank or peduncle was measured in millimeters at a point as near to the base of the ear as possible. Measurements were made on the same ears used for ear length determinations and were averaged for each collection.

Length of Peduncle. The length of the peduncle of the ear or shank was measured in centimeters from the point of its attachment to the stalk to the base of the ear. The measurements of five plants grown in Chapingo in 1949 were averaged.

Number of Husks. The husks (modified leaf sheaths) surrounding the ear were counted on the upper ears of each of five plants grown at Chapingo in 1949. The data are expressed as an average number per plant.

Kernel Width. The width of ten kernels taken from near the middle of the ear and laid side by side was measured in millimeters. The average for each collection was derived from measurements made on twelve to fifteen ears.

Kernel Thickness. The thickness of ten consecutive kernels in a row near the mid-point of an ear was measured in millimeters with metal calipers. The measurements were made while the kernels were on the ear, and the average for each collction was based on measurements made on twelve to fifteen ears.

Kernel Denting. Visual estimate recorded on an arbitrary scale: 0 = none; 1 = intermediate; 2 = maximum. Observations were individually recorded for twelve to fifteen ears of each collection, the scores being averaged.

Striations on Kernels. The longitudinal markings across the kernel caps made by the impression of the inner husk on the developing kernels were scored in three grades: 0 = absent; 1 = slight; 2 = prominent. The presence and prominence of striations is probably determined more by the morphology of the inner husk than by tightness of husk as was thought by Anderson (1946a). Some races have inner husks with a very coarse woody texture and prominent, coarse longitudinal veins, while other races have fine papery inner husks with anastamosing venation. There is a strong tendency for the more primitive corns to have the first type of inner husks and, consequentially, more prominent kernel striations, while the more modern races usually have almost tissue-paper-like inner husks and striations are often absent or very slight.

INTERNAL CHARACTERS

The internal characters of the ear (Table 16) were studied by breaking the ear approximately in the middle and examining the broken ends thus exposed under a dissecting microscope from which the stage had been removed. A magnification of 10X proved to be ample. These characters may also be studied, but somewhat less conveniently, with a pocket lens of approximately the same magnification. The ear can usually be made to break at the desired point by removing five kernels from each of four to six rows on one side, then bending the ear forcibly over a table's edge with the space from which the kernels have been removed centered on the edge. If the ear is later to be photographed or displayed it can easily be restored to approximately its original condition by joining together the two halves with a thermoplastic glue. Three to five ears of each race were measured and scored to give the averages in Table 16. To insure that the ears chosen for study were typical of a particular race, they were very carefully selected on the basis of the average measurements of the external characters for that race shown in Table 15. The characters included in our studies were as follows:

Ear Diameter. Measured in millimeters at the point at which the ear is broken. This measurement duplicates mid-ear diameter, given in Table 15 as one of the external characters of the ear, but a separate measurement is necessary in order to estimate rachilla length.

Cob Diameter. Measured in millimeters 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 in millimeters 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 glumes arise.

Kernel Length. Length in millimeters determined by measuring ten kernels from the middle of the ear, laid end to end.

Rachilla Length. According to Cutler and Cutler (1948) the rachilla becomes more compact as a result of teosinte introgression. Accurate measurements of rachilla length can be made only in histological sections but a very good estimate of rachilla length can be obtained from the data already available. 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. Rachilla length so estimated varies from 0.3, 0.4 and 0.4 in Arrocillo Amarillo, Palomero Toluqueño, and Pepitilla, respectively, to 3.6 and 4.3 in Cacahuacintle and Jala.

Cob/rachis Index. Computed by dividing the diameter of the cob by the diameter of the rachis. This index is quite useful in distinguishing races. It varies from 1.53 and 1.56 in Tehua and Jala, respectively, to 2.34 and 2.37 in Olotillo and Cacahuacintle. Other factors remaining constant, a high cob/rachis index indicates long glumes resulting from one of the intermediate alleles at the *Tu-tu* locus (Mangelsdorf and Smith, 1949). Introgression of teosinte appears to make the rachis tissue more prominent in relation to the glumes (which is the case in teosinte itself) and thus tends to reduce the cob/rachis index. Most of the races which show strong teosinte introgression, especially Jala, Tepecintle, Zapalote Chico, Zapalote Grande, Tuxpeño, Vandeño, Celaya, Cónico Norteño, Bolita, and Tehua have low cob/rachis indices.

Glume/kernel Index. This index gives a measure of the length of the glume in relation 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 kernel. The index varies from 0.30 in Pepitilla, which has long kernels and relatively short glumes, to 0.75 in Chapalote, which has short kernels and relatively long glumes. Other factors remaining constant, this index provides an excellent indication of the alleles at the *Tu-tu* locus[3] which are involved. Since the distribution of the races with respect to glume/kernel index is not continuous, it is possible to divide the races into three more or less distinct groups, which probably correspond rather closely to the *Tu* allele involved. Races with indices ranging from 0.30 to 0.48 are believed to be predominantly non-tunicate (*tu*). Those with indices from 0.52 to 0.63 are predominantly weak tunicate (tu^w). Those with indices from 0.67 to 0.75 are predominantly fourth tunicate (tu^f). It is to be noted that all four of the races in the group later to be described as "Modern Incipient" and six of the thirteen "Prehistoric Mestizos" are, by this criterion, to be considered as predominantly *tu* while half of the "Ancient Indigenous" races are tu^f.

Rachilla/kernel Index. Perhaps even more useful than rachilla length is the rachilla/kernel index which shows the length of the rachilla in relation to the length of the kernel. This varies from 0.02 in Pepitilla to 0.37 in Zapalote Chico. It is interesting to note that several races of maize which are thought to have been derived from Palomero Toluqueño, including Cónico, Cónico Norteño, and Pepitilla, have low rachilla/kernel indices.

Pedicel Hairs. The short pedicel upon which the pistillate spikelet is borne (actually an extension below the glume of the rachilla which bears the kernel) frequently bears at its base a small callus from which arises a distinct rosette of hairs (Cutler

[3] The existence of four alleles at the *Tu-tu* locus on the fourth chromosome; namely, tunicate (*Tu*), half-tunicate (tu^h), weak tunicate (tu^w) and non-tunicate (*tu*) was demonstrated by Mangelsdorf (1948). In addition Mangelsdorf and Smith (1949) point out that a condition intermediate between weak tunicate and half-tunicate, which produces approximately the same effect when homozygous as does half-tunicate when heterozygous may appropriately be called fourth-tunicate and tentatively be given the symbol (tu^f).

and Cutler, 1948). These hairs are almost or completely lacking in the four Ancient Indigenous races as well as in Maíz Dulce and Tepecintle. They are especially prominent in Cacahuacintle, Chalqueño (probably a derivative of Cacahuacintle), and Harinoso de Ocho. In other races there is considerable variability with respect to pedicel hairs. Teosinte introgression appears to reduce their prominence. For the purpose of tabulation the pedicel hairs have been arbitrarily scored as follows: 0 = no hairs; 1 = few short hairs; 2 = hairs intermediate in number and length; 3 = few long hairs; 4 = many long hairs.

Cupule Hairs. The cupule, a term used by Sturtevant (1899) to designate the depression in the rachis from which the spikelets arise, is almost invariably hairy. The hairs vary both in number and length from a few short prickles to many long, sometimes appressed hairs. The variation is so extensive that the characteristic alone is of little value. It may, however, be useful when considered with other characteristics and employed as part of the total description. Cupule hairs are especially prominent in number and length in Cacahuacintle and Harinoso de Ocho.

Rachis-flap. This structure, described by Cutler and Cutler (1948), and recently studied histologically by Lenz (1948) who defines it as an outgrowth of the cupule, is extremely useful in distinguishing races of maize. For our purpose we scored rachis-flaps arbitrarily as follows: 0 = none; 1 = weak; 2 = intermediate; 3 = prominent. Rachis-flaps are lacking or almost so in Palomero Toluqueño and Arrocillo Amarillo. They are prominent in Chapalote, Cacahuacintle, Comiteco and Jala. Lenz considers prominent rachis-flaps to be due to Tripsacum contamination, although Cutler and Cutler could find no correlation between rachis-flaps and chromosome knobs, also thought to be the product of Tripsacum contamination. Our own studies tend to confirm the Cutlers' observations. Certainly Cacahuacintle, which has especially prominent rachis-flaps, shows no other evidence of Tripsacum contamination. If teosinte (Tripsacum) introgression has any effect upon rachis-flaps it would appear in general to reduce rather than to increase their prominence. The presence of prominent rachis-flaps in certain segregates from maize-teosinte crosses reported by Lenz may trace back to the maize parent used in the cross and may have little to do with teosinte.

Lower Glume: Texture. The texture of the lower glumes is estimated by probing or puncturing with a dissecting needle. In some races the glumes are chartaceous or chaffy, often with considerable areas toward the margins, of thin transparent material resembling tissue-paper. In other races the glumes are fleshy and thickened, but soft, and yielding easily to the needle point. In still other races the glumes are distinctly horny and are difficult to puncture. Since the lower glumes of teosinte are almost always horny or bony and since this characteristic is transmitted to teosinte derivatives produced experimentally, the induration of the lower glumes is regarded as a good criterion of teosinte introgression. Although scoring the character is a subjective procedure involving a high degree of personal judgment, it is one in which different observers with a little experience will give strongly correlated opinions.

Lower Glume: Hairiness. The hairs of the lower glumes vary in number, length and position. Hairs are found almost universally on the upper margins of the glume. These vary from a few short hairs in Palomero Toluqueño to many long, soft hairs in Chapalote. The surface of the glume proper may be completely glabrous as it is in many ears of Palomero Toluqueño and in occasional ears of other races. More commonly a few hairs are found at the base or toward the lateral margins of the glumes. In Cacahuacintle and the related type Salpor the lower glumes are usually completely covered with numerous long, soft hairs. In general, the hairiness of the lower glume is not in itself a satisfactory diagnostic character, since there is often considerable variation within a race. Considered with other characteristics, however, it has some usefulness. There is some indication that teosinte introgression tends to reduce hairiness of the glumes.

Lower Glume: Shape of the Glume Margin. The upper margin of the glume varies in shape from race to race. The margin is rarely truncate and is usually more or less indented. The indentation may be luniform (crescent-shaped) as in Chapalote and Nal-Tel, more or less broadly angulate (wedge-shaped) as in some ears of Zapalote Chico, sinuate (undulate or wavy) as in Tabloncillo and Olotillo, or cordate (heart-shaped) as in Cacahuacintle and several other races. The shape of the margins is remarkably uniform among different ears of the same race and the characteristic is one which promises to be quite useful in distinguishing and describing races.

Upper Glume: Texture. The upper glume, like the lower, may be chaffy or fleshy. It is seldom horny.

Upper Glume: Hairiness. Hairs on the upper glume, like those on the lower, vary in number, length and position.

Upper Glume: Venation. Since the upper glume is usually thinner than the lower it frequently exhibits venation. In some races, however, the upper glume has become thickened and fleshy and the venation is obscured.

Upper Glume: Shape. The upper glume may as one extreme be wrinkled, as the other extreme stiff and collar-shaped, or it may be intermediate between these two extremes.

Rachis Induration. The surface of the rachis tissue varies in the degree of induration. This is probably a matter of degree to which the tissue is schlerenchymatized. Lenz (1948) has found conspicuous differences in varieties of maize with respect to the development of a schlerenchyma zone. An estimate of the induration of the rachis, like that of the lower glume, can be made by probing the rachis tissues with a dissecting needle. The induration has been arbitrarily scored as follows: 0 = no induration; 1 = slight; 2 = intermediate; 3 = strong.

Teosinte Introgression. An attempt has been made to estimate, from a study of the internal characteristics of the ear, the degree of teosinte introgression in the different races. This estimate is based upon a consideration of numerous characteristics but primarily upon the induration of the rachis and the lower glumes, and upon the number and length of the hairs on the glumes. Teosinte introgression has been arbitrarily scored as follows: 0 = no introgression; 1 = slight; 2 = intermediate; 3 = strong; 4 = very strong. Estimates of teosinte introgression are obviously highly subjective.

PHYSIOLOGICAL, GENETIC AND CYTOLOGICAL CHARACTERS

The characters included in this category (Table 17) are as follows:

Maturity. The number of days from planting to anthesis was taken as a measure of maturity. The date of anthesis for each collection was recorded when one-half of the plants in a plot containing fifty to sixty plants were shedding pollen. Data taken at Chapingo in 1945 and 1947 were averaged.

Corn Rust. The various races of maize when grown at Chapingo exhibited considerable differences in reaction to the race or races of rust (*Puccinia sorghi Schw.*) present. Each race of maize was rated with respect to degree of resistance or susceptibility on the basis of 1 to 5, 1 being highly resistant and 5 highly susceptible. No attempt has as yet been made to identify the races of rust involved.

Pilosity. Many of the maize varieties have strongly pubescent or pilose leaf sheaths. Mangelsdorf (unpublished) has found that the inheritance of pubescence is relatively simple and is dependent upon two principal genes, one of which is definitely located on chromosome 9 and the other of which is probably on chromosome 3. Pilosity of the leaf sheath is a character of the maize of high altitudes in Mexico, Guatemala and Colombia. It attains most prominent development in Mexico in the race Cacahuacintle. It is possible that the pilosity of Palomero Toluqueño is due to the reciprocal introgression of these two races into each other through Cónico, the progeny of their racial hybridization. Pubescence in Table 17 is arbitrarily scored from 0–5, the higher number indicating the stronger pubescence.

Plant Color. The high-altitude races of Mexico, Guatemala and Colombia have strongly colored leaf sheaths. This color is sometimes due to the *B* factor on chromosome 2, sometimes due to one of the *R* alleles on chromosome 10, and sometimes results from both. The empirical scores in Table 17, ranging from 0–5, do not distinguish between these two genes for color. Color, like pubescence, reaches its maximum in Cacahuacintle. A visual estimate was made in a plot of from fifty to sixty plants of each collection taking into consideration both frequency and intensity of the plant color to arrive at an arbitrary score.

Mid-cob Color. First described by Demerec (1927), mid-cob color affects the tissues between the pith and epidermis of the rachis. It is seen only when the cob is broken and for this reason its widespread distribution in Mexican races has been largely overlooked. Recent studies by Mangelsdorf (unpublished) indicate that mid-cob color is the result of an allele of *R* on chromosome 10. The data recorded represent an average percentage of the ears that had mid-cob color. Approximately fifteen ears of each collection were read for this character.

Chromosome Knobs. Longley (1938) and Reeves (1944) have shown that chromosome knob number in maize is negatively correlated with distance from some point in Mexico or Guatemala. Mangelsdorf and Cameron (1942) found knob number in Guatemala to be associated with altitude and to be strongly correlated with a number of morphological characters, some of which are themselves associated with altitude. Actually, chromosome knob number is a racial characteristic and is probably highly correlated with the amount of introgression of teosinte which a race has undergone. Variation in knob number in Mexican maize, ranging from zero to fourteen, is not quite as wide as it is in Guatemalan maize where Mangelsdorf and Cameron found numbers ranging from one to sixteen. All of the Ancient Indigenous and Pre-Columbian Exotic races which have been studied have relatively low chromosome knob numbers, six or less. All of the Prehistoric Mestizos and Modern Incipient races except Cónico and Comiteco have relatively high knob numbers, more than six. Chromosome knob number is correlated to some extent with induration of the rachis.

An increase in chromosome knob number at least up to a certain point seems sometimes to have been favored by natural selection in the development of the Mexican races of maize. The average knob number for races of hybrid origin is higher than the average knob number of their two putative parents (Tables 3–12). Six of the suspected hybrid races for which data are available, Jala, Zapalote Chico, Cónico Norteño, Vandeño, Chalqueño and Celaya, have higher knob numbers than the average of their supposed parents and the last three have higher knob numbers than either parent. Samples are not large enough to establish this relationship beyond question but there is at least an indication that when two races cross, there is a tendency for the chromosome knobs of both to be preserved in the hybrid. This would be expected to occur if the knobs themselves serve a useful purpose (as, for example, in improving the nucleic-acid balance) or are associated with blocks of teosinte genes which have a favorable effect upon the general characteristics of the plant. Knob numbers would also be higher in hybrids if there is any mechanism for maintaining heterozygosity.

GEOGRAPHICAL DISTRIBUTION

A better understanding of the distribution of the various races may be had by first studying the general topographic and climatic conditions of the different areas of Mexico. (As a matter of convenience in orientation, a map (Fig. 5) showing the locations of the 28 states of the Republic, is included.) From an agricultural viewpoint the country comprises a number of well-defined natural regions as shown in Fig. 6. The range of mountains extending north from Guatemala through the Isthmus is divided in the south central area into two ranges, the Sierra Madre Oriental on the east and the Sierra Madre Occidental on the west. Between these lies the great plateau of Mexico. This plateau can readily be divided further from north to south into five general regions, indicated in Fig. 6 as follows: (1) Northern Mesa; (2) Northern Bajio; (3) Jaliscan Plains; (4) the Bajio; and (5) the Central Mesa. The Northern Mesa is a continuation of the basin and plateau country of Arizona, New Mexico and western Texas. It consists chiefly of vast stretches of nearly level land, covered with short grasses, mesquite and cactus. Its low annual rainfall of from twelve to fifty centimeters, irregularly distributed, makes it of little value for the cultivation of crops. Because of this aridity the principal use of the land is for grazing, except in an area around Torreon where a small irrigated region known as La Laguna is devoted to the production of wheat and cotton. The Northern Mesa comprises about twenty percent of the total area of Mexico but con-

Fig. 5. Map showing locations of States in Mexico.

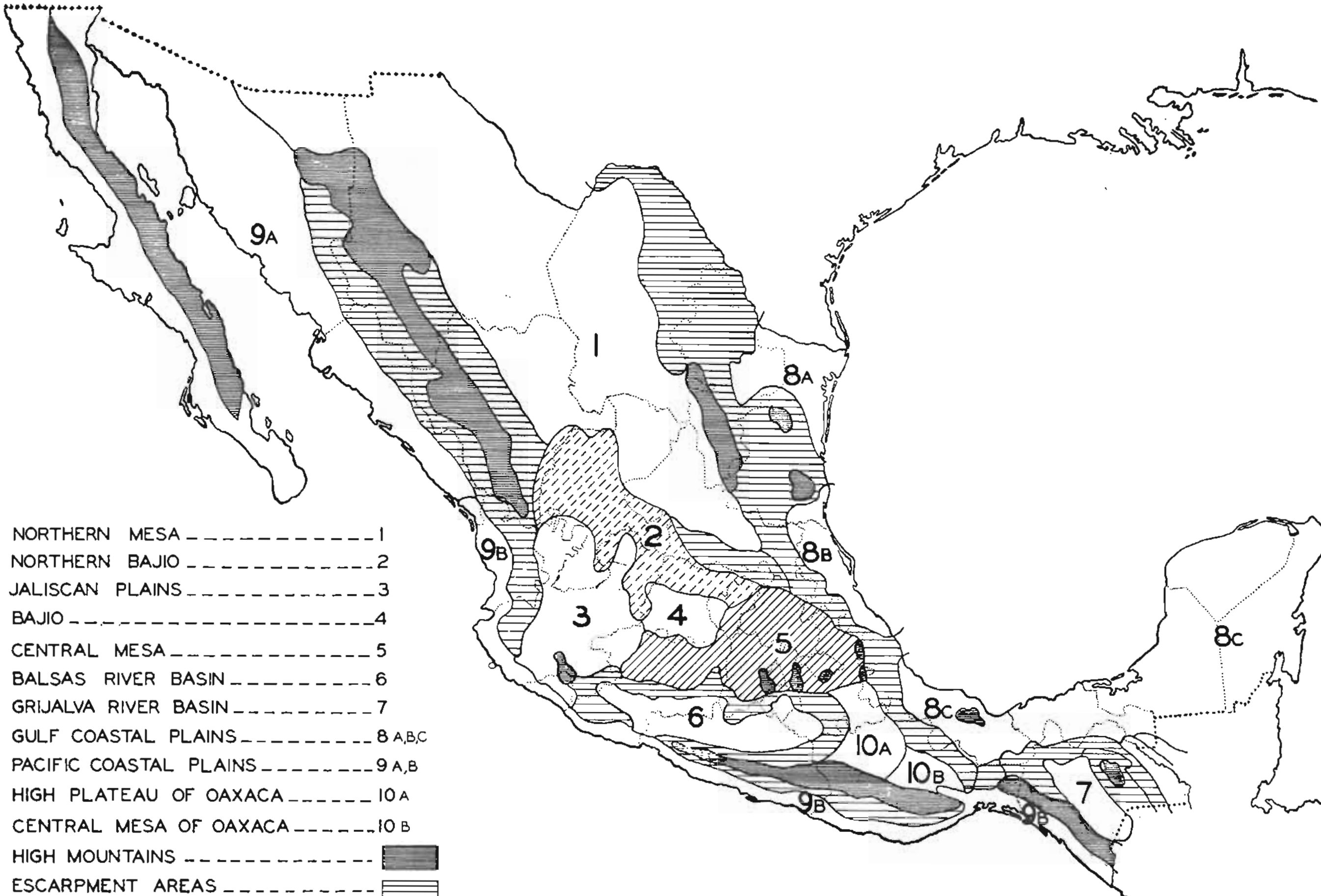


FIG. 6. Map showing geographical regions of Mexico. (Modified from C. L. Gilly Jr. and H. S. Gentry, Geographical Regions of Mexico.)

tains a very small fraction of the population. This is in sharp contrast to the four areas in the southern part of the great plateau, where over half of the people live in an area comprising about twelve to fifteen percent of Mexico. The difference is rainfall. Here the average rainfall between June and October varies from about fifty to one hundred centimeters which, together with its seven to eight extensive flat-bottomed valleys from 1500 to 2600 meters in elevation, has made this area the most important corn region of the nation.

The escarpment areas bordering the great plateau on the east, west, and south consist primarily of small steep-sloped valleys and narrow ridges with little level ground either in valley floors or in interfluvial spaces. On the east and south rainfall is sufficient, but very little of the terrain is adapted to agriculture. Corn is generally grown on the small alluvial valley floors and very often on the ridges or steep slopes up to 3000 meters above sea level. Most of the small valleys are isolated from each other by high ridges and rough terrain. Not only are they isolated one from another but they also may vary considerably in elevation. These conditions have been very conducive to the development of many different varieties of corn.

The western escarpment area is semi-arid with many of the interfluvial areas being too dry for farming. Characteristic of the western escarpment are the deep-cut barrancas through which flow the few rivers that cross its surface and which now provide water for irrigation, in some of the more level areas of the Sonoran desert (Fig. 6, region 9a), for the production of sugar cane, tobacco, cotton and tropical fruits. One of the largest irrigation projects in the Sonoran desert of relatively recent origin is in the Yaqui Valley which produces substantial commercial quantities of rice, wheat and flax.

Wedged in among the highlands of southern Mexico are several relatively large plateaus and river basins. Some of the high and low plateaus of Oaxaca (Fig. 6, regions 10a and 10b) are well suited to agriculture and are well populated. Much of the Oaxacan high plateau is quite similar to the Bajio in both elevation (1500–1800 meters) and climate, but the varieties of corn are distinct. The Balsas River Basin in the northern part of the state of Guerrero (Fig. 6, region 6) varies in elevation from 450 to 1500 meters. Because of its climate and rough terrain it is not densely populated. The Grijalva River Basin in the state of Chiapas is somewhat smaller but similar to the Balsas area in both elevation and climate. Although widely separated, certain races of maize have been found to be the same in both areas.

Along the Gulf coast is a comparatively narrow strip of lowland called the Gulf Coastal Plain which widens out in the Yucatán Peninsula (Fig. 6, regions 8a, b, c). The Pacific Coastal Plain (Fig. 6, regions 9a and 9b) is very narrow except in the north where there is a wider strip of low level arid land generally known as the Sonoran Desert and Plain. Lower California, except for a ridge of mountains on the east side, is much like the Sonoran desert.

The west coast is generally too dry and the east coast, with the exception of Yucatán, too hot, humid and unhealthy for most inhabitants. Most of these areas are sparsely populated. Rainfall during the rainy season on the east coast varies from 125 centimeters in the north to about 300 centimeters in the state of Tabasco. The northern part of the Yucatán Peninsula has no mountains to precipitate moisture from the gulf winds and is comparatively dry. For many centuries this region has been densely populated and has been the home of a relatively advanced civilization. The porous coralline limestone soil together with a scarcity of rainfall has made it difficult to grow corn but certain varieties have been adapted to the climatic conditions and have afforded the inhabitants a means of subsistence.

From the mountains and plains of these different natural regions approximately 2,000 samples of corn have been collected. The work was initiated in the fall of 1943 and winter of 1944 by special systematic collecting trips throughout the Central Mesa. Most of the important villages within the Central Mesa were visited and the types of corn within them sampled at random. Samples usually consisted of fifteen to twenty-five ears picked at random from each of several cribs within the village, or where possible, directly from the surrounding fields. It was soon found, however, to be much easier to get samples representative of the corns of a certain village by waiting until the corn had been harvested and brought

Fig. 7. Map showing where collections have been made. Each dot may represent one or more collections.

into the village for storage. Each year since 1943 collections were made by special trips into new areas in a similar systematic way and as shown in Fig. 7 most of the important areas of Mexico except for the North have now been fairly well covered. The different places from which samples of corn have been collected are shown on the map in Fig. 7 by small dots each of which may represent one or more collections. Most of the collections, as evident from the distribution of the dots, were made in the southern half of Mexico including the southern part of the great plateau, the southern and Chiapas highlands, the coastal areas and the northern part of the Yucatán Peninsula. What exists in those areas from which no collections have been obtained remains to be determined. By comparing the map in Fig. 7 with the one giving the natural regions, Fig. 6, it is evident that many of the blank spaces on the former are deserts or otherwise uninhabitable mountainous terrain. Others are places very difficult to reach or, as in much of northern Mexico, represent areas in which no special effort to collect corn has as yet been made. Except for a recent expedition to Sinaloa and Sonora, the scattered samples available from the northern areas were sent or brought in by various individuals interested in this study.

It is from the general map (Fig. 7) that the distribution maps for the various races have been made. A sample was considered as belonging to a particular race when it did not show more than approximately twenty percent introgression, on an arbitrary scale, of some other race or races as nearly as could be estimated from a study of the plants and ears. As in the general map, the locality in which a sample of a certain race was collected is indicated by a small circle.

Since collections have not been made in all areas, the geographical distribution of a particular race may not have been finally determined. Some of the primitive races are only very rarely found. In some cases the same race may be found in areas at the same altitude but widely separated. Often centers are found in which certain races predominate but as one moves out from these centers more and more inter-mixture is noted. Where such centers can be located and the introgression of another race is rather clearly defined, this is shown on the maps.

Sometimes several races have the same spatial geographical distribution but exist at different elevations. Also distinct races often are maintained in the same area because of different uses or because of differences in their maturities. Where two or more races overlap or occupy the same area different maps are used to show their distribution. The number of circles representing a particular race on a map is not indicative of its prevalence or the amount of this type of corn grown. For example, in western Mexico three races and one sub-race, Tabloncillo, Reventador, Maíz Dulce and Elotes Occidentales, occupy the same general area. The last three can usually be found on a limited scale in most villages but it is the first, Tabloncillo, which occupies most of the land each year. Prevalence of a particular race is discussed under the section on distribution of each individual race. The maps merely show localities from which collections were made.

ORIGINS AND RELATIONSHIPS

Conclusions with respect to relationship are implicit in any natural classification. In the case of the races of maize in Mexico it is possible to be more than ordinarily specific about relationships since many of the races are hybrids of still-existing races, and their origin is quite clear. A race is suspected to be of hybrid origin when it is clearly intermediate in certain of its ear and plant characters between two races which occupy adjacent areas or overlap in their distribution or when there is a good reason to believe that they have done so in the past. The hybrid origin of a particular race in question becomes much more certain when an analysis of the data of the various characters measured and observed independently of any preconceived hypothesis show it to be intermediate between its supposed progenitors in a large number of its characteristics. Tables 1–12 have been prepared especially to show the comparison of the supposed hybrid races with their putative parents in a large number of characters measured. In some races, especially Zapalote Grande, Tuxpeño and Chalqueño (Tables 6, 7 and 9 respectively) the evidence for the hybrid origin postulated is truly striking.

Further evidence of hybrid origin is sometimes obtained from inbreeding which isolates types resembling the putative parents. Finally the hybrid race can sometimes be synthesized, or at least something very much like it can be produced, by crossing the two putative parents. When this can be done little reason remains for doubting its hybrid origin. All of the Mexican races suspected of being of hybrid origin have not yet been synthesized but since those which have been support completely the conclusion about their suspected hybrid origin, odds favor the assumption that at least the majority of the remaining races will prove, on the basis of subsequent experimental evidence, to be what their characteristics now suggest them to be.

A hypothetical genealogy of each of the suspected hybrid races is given in connection with the discussion of its origin. Some of these genealogies, especially of the Modern Incipient races, are exceedingly complex and at first glance impress one as being somewhat speculative and far-fetched. They are built up, however, from more simple genealogies, a number of which are well established, and most of which have at least some evidence in their support.

EXISTING RACES OF MAIZE IN MEXICO

There is probably no "pure" race of maize in the sense that the individuals comprising a race are homozygous for all or a majority of their genes. Indeed, in open-pollinated varieties of maize every plant is probably slightly genetically different from every other plant. Anderson and Cutler (1942) have defined "race" as it applies to maize as ". . . a group of related individuals with enough characteristics in common to permit their recognition as a group." This definition is the basis for the present classification.

It is now possible to recognize at least twenty-five distinct races of maize in Mexico. This is not to say that all of the maize found in Mexico can be assigned to one of these recognized races. On the contrary, perhaps the majority of varieties collected in Mexico are mixtures of two or more races. Nevertheless, once the principal races are recognized it is usually possible to discern the different racial elements which have entered into any particular mixture. The situation is comparable to breeds of livestock or dogs. The so-called pure breeds are easily recognized even by the layman who has no difficulty in distinguishing a St. Bernard from a Scotch Terrier, or a Holstein cow from a Hereford. The breeder or fancier can go further; he can frequently identify the breeds which have hybridized to produce the characteristics found in any particular mongrel.

According to their derivation the races of maize in Mexico may be divided into four major groups as follows: A. Ancient Indigenous; B. Pre-Columbian Exotic; C. Prehistoric Mestizos; D. Modern Incipient; and an additional group designated E, "poorly defined" races.

Each of these groups comprises several races. In naming the races we have followed Anderson and Cutler (1942) in avoiding Latin names. Wherever possible we have employed the Mexican name by which the race is commonly known in the region where it is grown. Some of these names are Indian and some are Spanish; some are descriptive and others are place names. With a few exceptions, however, all are names given to the maize by the people themselves. In the few instances where an appropriate local name was not available we have assigned to the race a descriptive Spanish name. Some of the races described in this publication have previously been described or referred to under English names by other writers. The Mexican Pyramidal and Guatemalan Big Grain of Anderson and Cutler (1942), for example, are for the purposes of this paper called Cónico and Olotón, respectively. Anderson's (1946a) Mexican Narrow Ear is called Tabloncillo, a well-known local name for this type of maize.

ANCIENT INDIGENOUS RACES

Ancient Indigenous races are those which are believed to have arisen in Mexico from the primitive pod corn whose remains, as mentioned earlier in this paper, have recently been found in New Mexico. The several races in this group differ from each other by virtue of their independent development in different localities and in different environments, but having descended from a common ancestor without hybridization they still retain many important characteristics in common. The word indigenous as used here does not imply that these varieties necessarily originated in

Mexico but merely that they have been there so long that they are indigenous when compared to other varieties that were introduced or developed later.

Four of these races, Palomero Toluqueño, Arrocillo Amarillo, Chapalote and Nal-Tel are now recognized. All, like their primitive ancestors, are pop corns. Two of the four, Chapalote and Nal-Tel, are forms of weak pod corn. All have small ears. All are relatively early in maturity, at least in the regions in which they are grown. All of them resemble in some characteristics the prehistoric corn of South America. Palomero Toluqueño and Arrocillo Amarillo have been found only at high altitude (above 2,000 meters), whereas the other two have been found only in tropical areas at elevations of approximately 100 meters. Nevertheless, the two tropical races produce fairly normal ears when grown at Chapingo, Mexico, at 2,200 meters elevation, which is not true of many of the more modern tropical varieties. This suggests that the ancient varieties are less sensitive to change at least in altitude than the more modern types.

There is little doubt that additional races belonging to the Ancient Indigenous group of maize varieties will be found when a thorough search is made for them in isolated localities, especially at high altitudes. Indeed, one of the four races now included in this group, Arrocillo Amarillo, was discovered quite recently as a result of a special search made for it. Some of the maize in the northern part of the state of Puebla showed evidence of an introgression of a small-eared, small-seeded, yellow variety. On the basis of this evidence a special search for a maize of this type was made and several collections of it were obtained in the area where its occurrence had been suspected. Similar races of pop corn will no doubt be discovered in other isolated localities at high altitudes in Mexico, for mountain heights, like ocean islands, are important factors in the isolation and differentiation of races and species. Few countries offer greater opportunities for such factors to play their role than Mexico.

The description, distribution, origin and relationship of each of the races in this group is given below.

PALOMERO TOLUQUEÑO

Plants. Very short, approximately 1.7 meters; early in maturity; few tillers but those present approach height of main stalk; strong tendency to lodge due to poorly developed root system; leaves sparse, averaging 12.2 per plant, drooping, narrow and

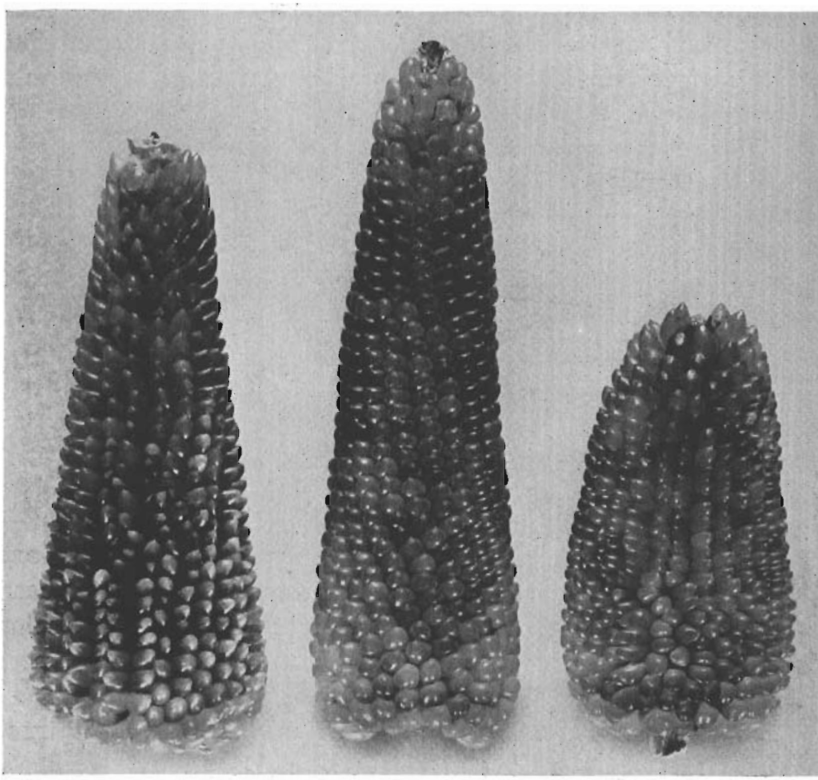
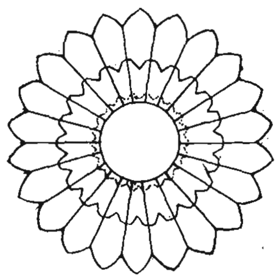


FIG. 8. Palomero Toluqueño, a primitive race of rice-type popcorn that is still grown to a very limited extent in the Central High Plateau. Note the spreading of the pistillate spikelets on the ear to the left. Scale 1 cm = 1.31 cm.

short but fairly long in relation to width; low venation index; strong sun-red color and highly pubescent; highly resistant to races of *Puccinia sorghi* present in central plateau of Mexico; very low number of knobs ranging from 0–4, average 1.2. In Mexico adapted only to high elevations, 2,200–2,800 meters.

Tassels. Very short; thickened central spike; very few branches, averaging 3.6 per tassel, arising in a short space on the main axis; secondary branches very few to absent, tertiary branches absent; condensation index among highest of races.

Ears, External Characters. (Fig. 8) Length short to very short; conical shaped, acute uniform taper from base to tip; high row number, 20 and above; kernels arising from a pair of spikelets whose two members are often spread apart at an angle; mid-cob color usually absent; shank diameter small; kernels of rice-like, pop-corn type, small, both narrow and thin but fairly long in relation to width and thickness; strongly pointed, often beaked; denting absent; husk striations absent to very slight, occurring on basal kernels only; endosperm highly corneous, of a grayish white color; aleurone colorless with aleurone inhibitor factor common; pericarp colorless.



PALOMERO TOLUQUEÑO

FIG. 9.[4]

Ears, Internal Characters. (Fig. 9) Ear diameter 30–36 mm.;

[4] This diagram and all similar ones which follow were drawn according to actual measurements of the internal characters of the ear and are reproduced in natural size unless otherwise stated. All measurements are based on an average of 3 to 5 typical ears. These diagrams show the ear in cross section as four concentric circles; the inner one encloses the zone of rachis tissue, the second one (dotted line) marks the limits of the length of the rachilla or the point at which the base of the kernel is attached to the rachilla, the third encloses the zone of glume tissue and the fourth or outer circle represents the circumference of the ear at the mid-point of its length. From these diagrams the diameter of the ear, cob and rachis, the length of the kernel and rachilla and their inter-relationship is readily apparent. In addition the actual form of the dorsal side of the kernel and of the lower glume margin may be had at a glance. By comparing the diagrams in Plates II to VI, the similarities and differences between the various races in respect to the above mentioned characters may be easily noted.

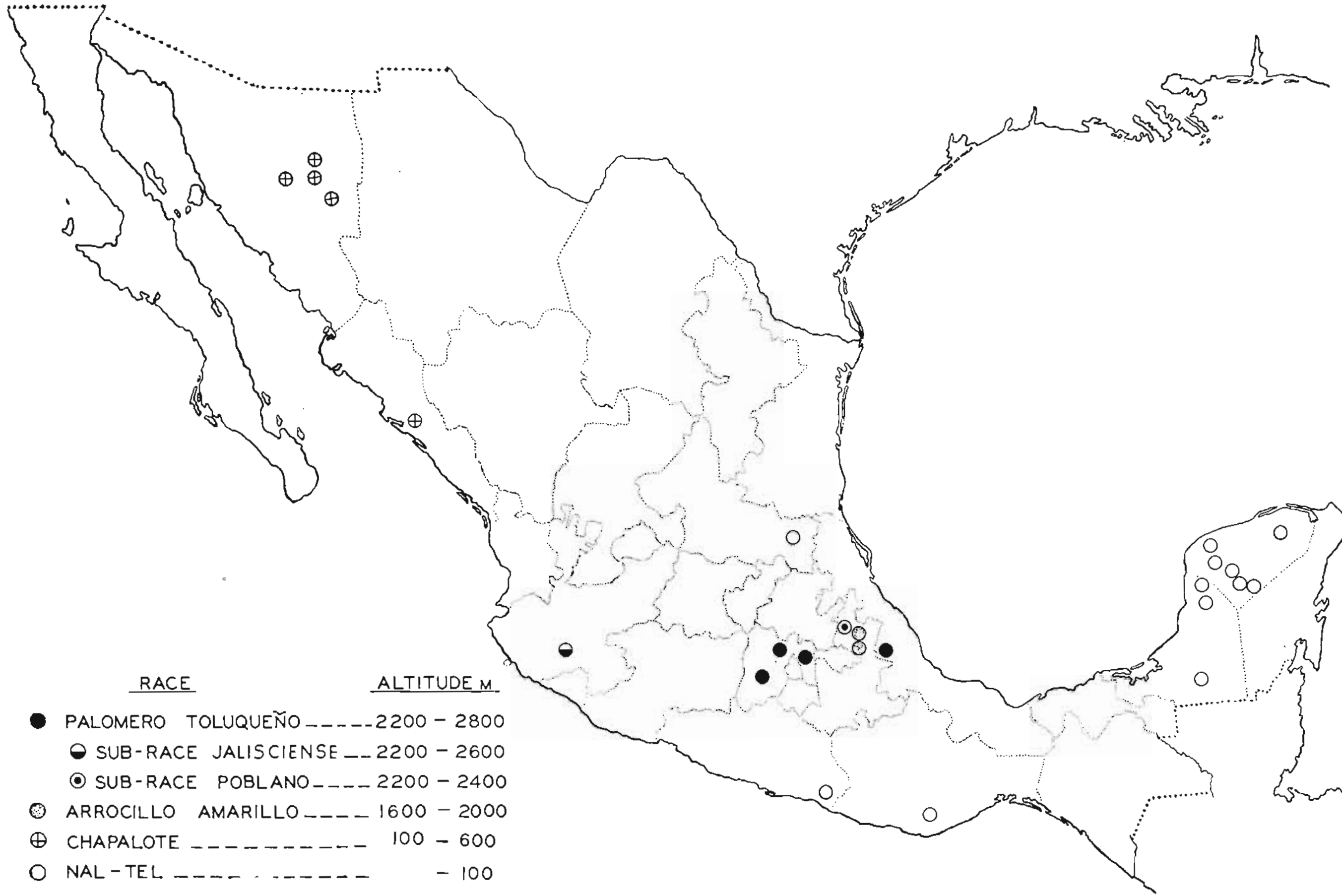


FIG 10. Map showing distribution of the four ancient indigenous races and sub-races.

cob diameter 17–22 mm.; rachis diameter 10–11 mm.; kernel length 10–13 mm.; estimated rachilla length 0.4 mm.; cob/rachis index medium, 1.88; glume/kernel index low, 0.40; rachilla/kernel index very low, 0.04; pedicel hairs none; cupule hairs intermediate in number and length; rachis flap none; lower glumes mainly chaffy, about 1/3 of area transparent, few marginal hairs, surface hairs few or lacking, the margin angulate; upper glumes tissue-thin to chaffy, strongly veined, wrinkled, marginal hairs few or none; tunicate allele, predominately *tu*; rachis tissue spongy; teosinte introgression none or very slight.

Distribution. The distribution of Palomero Toluqueño is shown in Fig. 10. It is now strictly a high altitude race. In its pure form it has practically become extinct but it is still to be found in a few places in the Mesa Central at elevations varying from 2,200 to 2,800 meters. It is more common in the valley of Toluca (2,600 m.) than elsewhere, but even here it has been almost entirely replaced by the more productive Prehistoric Mestizo, Cónico, which was derived from it. Although a pop corn, it is little used for popping probably due to its poor quality and low popping volume. Samples have been collected principally near Toluca and San Mateo Atenco in the state of Mexico and Tres Cumbres, Morelos. One sample was also collected at Sierra de Agua in Veracruz, at high elevation.

It seems probable that this ancient indigenous race of pop corn may once have been very widely distributed at high elevations in the Central Plateau and that in certain isolated areas subraces were developed. Two of these will be described later.

Origin and Relationships. This race is probably an ancient one. It is primitive in having small flinty seeds which are capable of popping and in having striations on the basal kernels. It also exhibits strong spreading of the pistillate spikelets accompanied by marked tesselation in alternate rows. This probably is a primitive characteristic since it occurs in other races which are regarded as primitive including the Guarani maize of Paraguay. The race does not, however, have the prominent glumes characteristic of some of the other primitive races, and its rachilla is very short indeed. Prehistoric charred remains of kernels of this race have been identified in the private archaeological collection of Mrs. William Stone of Mexico City. Perhaps the best evidence of the antiquity of Palomero Toluqueño is the fact that it is undoubtedly one parent of the race Cónico, which has become the predominating race on the Mexican Plateau and which in turn has given rise to several modern races, Chalqueño and Cónico Norteño. It has also played a part in the origin of Pepitilla. The relationship of Palomero Toluqueño to Cónico, Cónico Norteño and Pepitilla is perhaps best demonstrated by the diagrammatic cross sections (Plates II, IV and VI). These show clearly the short rachillae, relatively short glumes and long kernels which are common to all of these races. A race which has both primary and secondary derivatives must itself have attained a respectable age.

Characters of this race are more strongly evident today in the Cónico corns grown above 2,600 meters in the Central Plateau. Plants for the most part are very similar and the ears are slightly larger in size but very similar to Palomero Toluqueño in high row number and small kernels.

Derivation of Name. "Palomero" is the name commonly used for this type of corn in the region where it is grown but its derivation is unknown. Since this race is most commonly found in the valley of Toluca, it was named Palomero Toluqueño.

References. Kuleshov, 1930; Khankhoje, 1930; Anderson, 1944b, 1946a; West, 1948; Bautista R., 1949.

Sub-races of Palomero Toluqueño

Palomero Poblano

This sub-race occurs in a limited area in the vicinity of Xalacapa, Puebla, at elevations of 2,200 to 2,400 meters, somewhat lower than the elevations at which Palomero Toluqueño is commonly found (Fig. 10). It also has softer textured kernels with a tendency to more pronounced pointing than is found in Palomero Toluqueño. This suggests that it may be one of the intermediates in the relationship that exists between Palomero Toluqueño and Pepitilla, a semi-tropical race.

Palomero Jalisciense

This sub-race occurs primarily in the mountain area of southern Jalisco (Fig. 10) and on the slopes of "Volcan de Colima" in

Jalisco at elevations of 2,600 to 2,700 meters. In comparison to Palomero Toluqueño it is slightly more vigorous, has a stronger root system, and is later in maturity. Also the ears are somewhat less tapering than those of Palomero Toluqueño. These modifications probably have been brought about through the introgression of Olotón, a race common to the high altitudes of the state of Chiapas in Mexico, and in Guatemala. Although Olotón as it exists in the highlands of Chiapas and Guatemala has not been found in the mountains of southern Jalisco, its influence is clearly evident in the variety complex of this region.

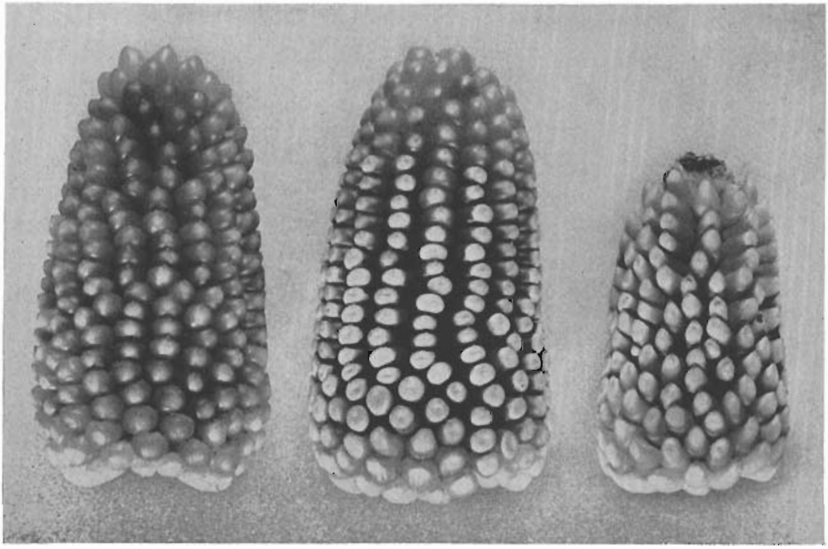


FIG. 11. Arrocillo Amarillo, a race undoubtedly closely related to Palomero Toluqueño but differing from it in having a more slender ear, shorter kernels and yellow endosperm. Typical ears are found as segregates in the early pop-corn-like varieties grown at high altitudes in the state of Puebla. Scale 1 cm. = 1.15 cm.

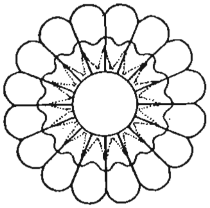
ARROCILLO AMARILLO

Plants. Not yet studied in cultures. Adapted to elevations of 1,600 to 2,000 meters.

Tassels. Not yet studied.

Ears, External Characters. (Fig. 11) Very short, conical yellow ears with a medium number of rows; rows averaging 15.4 in number. Pop-type kernels small, very narrow and thin, rounded, awlshaped, without denting; slight striations throughout the ear; endosperm highly corneous, yellow; aleurone colorless; pericarp colorless. Prolific, usually producing two or three ears per stalk.

Ears, Internal Characters. (Fig. 12) Ear diameter 26–28 mm.; cob diameter 14–17 mm.; rachis diameter 7–9 mm.; average kernel length 8.4 mm.; estimated rachilla length 0.3 mm.; cob/rachis index medium 1.86; glume/kernel index low, 0.41; rachilla/kernel index very low, 0.03; pedicel hairs lacking or few; cupule hairs variable; rachis flap none; lower glumes fleshy to slightly horny, surface hairs few, short, or lacking, marginal hairs few, short; glume margins broadly angulate; upper glumes chaffy, weakly



ARROCILLO AMARILLO.

FIG. 12.

veined, wrinkled, surface hairs few or lacking, marginal hairs few, short, or lacking; rachis tissue spongy to horny; tunicate allele predominantly *tu*; teosinte introgression slight.

Distribution. Arrocillo Amarillo, in its purest form, has been found in the vicinity of Xalacapa, Puebla, north of the state of Tlaxcala, in the Mesa Central at elevations of 1,600 to 2,000 meters (Fig. 10). This race, like Palomero Toluqueño, is practically extinct. Its influence, however, is strongly evident in the varieties around Oriental, Tezuitlan, and Zaragoza, Puebla, north of the state of Tlaxcala. Also, its influence in more diluted form is evident in many of the varieties of the race called Cónico throughout the state of Puebla, Tlaxcala and adjacent high altitude areas in Veracruz. Its distribution is limited to high altitudes but it is adapted to elevations somewhat lower than is Palomero Toluqueño.

Origin and Relationships. This race is undoubtedly closely related to Palomero Toluqueño. It resembles it in almost all of the internal characteristics of the ear including a very short rachilla and absence of pedicel hairs and rachis flaps, but differs from it in having a more slender ear, cob and rachis, shorter kernels, yellow endosperm, and in the absence of spreading of the spikelets. Whether these characteristics have resulted from introgression from another race still undiscovered remains to be determined. This race has been only recently collected and needs to be studied more fully before its origin and relationships can be determined. Arrocillo Amarillo with Palomero Toluqueño and its sub-races, Poblano and Jalisciense, undoubtedly represent relicts, often strongly contaminated by other races, of a complex of primitive pop corns once widely distributed in Mexico. Differentiation within this complex was brought about through isolation on geographically separated mountain ranges or peaks. Survivors of this complex are most likely to be found today only in isolated localities at high altitudes where they have not yet been completely replaced by modern races. Indeed, Arrocillo Amarillo, as has already been mentioned, was discovered under such conditions as a result of a special search made for it.

Derivation of Name. Arrocillo, a local name, means "little rice" and refers to the rice-like grains characteristic of this race. Amarillo refers to the yellow color. Hence the name Arrocillo Amarillo.

CHAPALOTE

Plants. Short, averaging approximately 1.6 meters at Chapingo, somewhat taller in native habitat; early maturing; tillers profuse; stalks slender; medium number of leaves, narrow and long; venation index lowest of races; color and pubescence almost lacking; highly susceptible to rust. Knob number average 6. Best adapted to low elevations but produces fair ears up to 1,800 meters.

Tassels. Short, few to medium number of branches fairly widely spaced on main axis; secondaries few, tertiaries absent; condensation index very low.

Ears, External Characters. (Fig. 13) Short to medium length; slender; cigar shaped with slight tapering at both base and tip; average number of rows 12.3; tesselated; shank diameter low, mid-cob color present in about 50% of the ears, kernels small, rounded and smooth; husk striations pronounced throughout

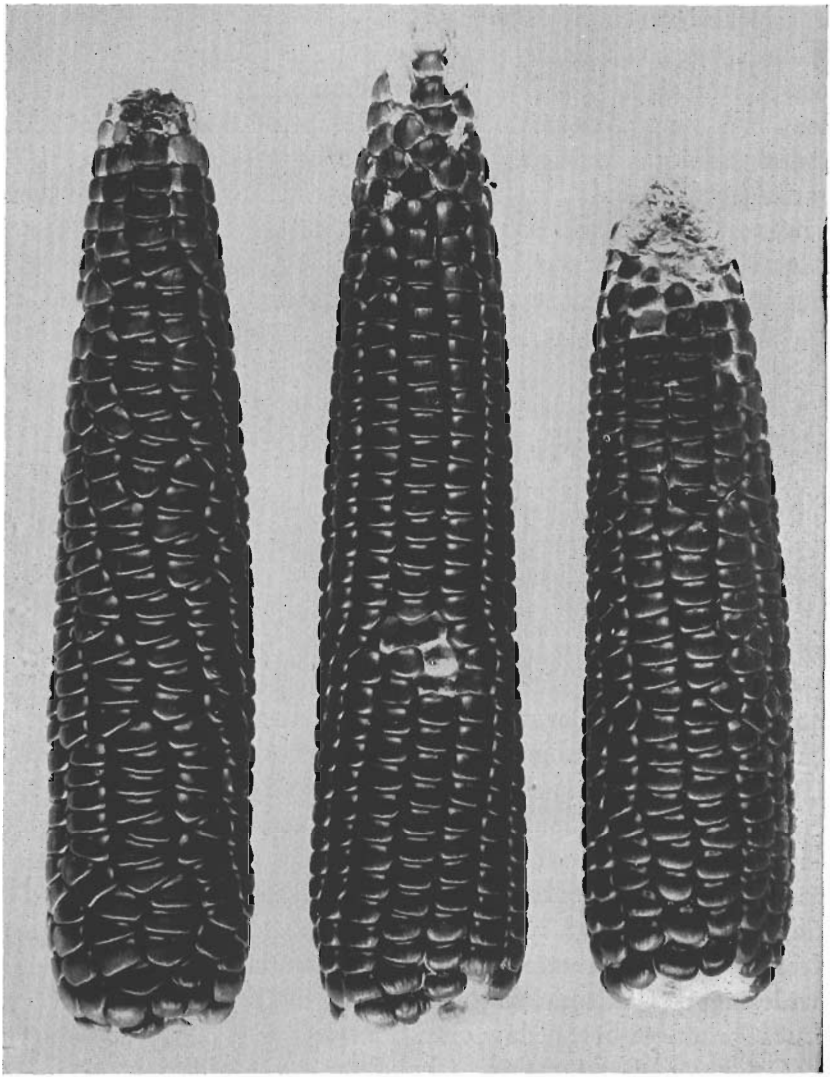
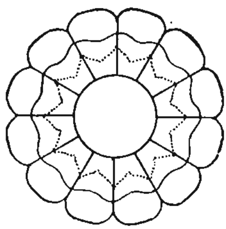


Fig. 13. Chapalote, a primitive race of pop corn found in a very restricted region in the state of Sinaloa on the west coast of Mexico. The ears are small, cigar shaped with small, flinty seeds having chocolate pericarp color. Almost all the ears are weak pod corn and show prominent husk striations on the kernels.
Scale 1 cm. = 1.17 cm.

length of ear; endosperm white, horny, pop type; aleurone colorless; pericarp usually brown.

Ears, Internal Characters. (Fig. 14) Ear diameter 28–30 mm.; cob diameter 21–23 mm.; rachis diameter 11–12 mm.; kernel length 6–8 mm.; estimated rachilla length 1.8 mm.; cob/rachis index medium to high, 1.96; glume/kernel index high, 0.75; rachilla/kernel index high, 0.25; pedicel hairs none; cupule hairs few, very long; rachis flap very prominent; lower glumes fleshy to slightly horny, surface hairs few and long, marginal hairs long, margin shape luniform; upper glumes chaffy, venation intermedi-



CHAPALOTE

FIG. 14.

ate to strong, shape intermediate to wrinkled, marginal hairs long; tunicate allele probably tu^{l}; rachis tissue spongy to slightly horny; teosinte introgression slight.

Distribution. Chapalote has been found only in the coastal lowlands of the states of Sinaloa and Sonora in northwestern Mexico (Fig. 10). It was collected around Culiacan in Sinaloa and at Sahuaripa, Suaqui, Ures and Moctezuma in the state of Sonora, from 100 to 600 meters elevation. It is adapted to a relatively wide range of altitude, forming ears up to 2,200 meters elevation, but it produces best at low elevation.

Origin and Relationships. Chapalote is one of the most distinctive races of maize in Mexico. It is primitive in being not only a pop corn but also a form of weak pod corn. It has the highest glume/kernel index of any race in Mexico. It also exhibits prominent striations on the kernels, another primitive character. All of these primitive characters are accentuated in certain segregates upon inbreeding. For example, one inbred ear showed a highly tunicate condition, deep striations on the kernels, very spongy rachis tissue, and very long hairs on the margins of the upper and lower glumes. There was little or no evidence of teosinte introgression in this ear.

One of the most distinct characteristics of Chapalote is its brown pericarp color which in hybrids with many other varieties is transformed to pink or red. This color is probably due to to an allele at the *A* locus on chromosome 3 affecting one of the alleles at the *P* locus on chromosome 1. Anderson (1944a) compares the pericarp color of Chapalote with the brown pericarp color of teosinte, but it is doubtful if they are genetically the same since the genotype of teosinte is usually *A*. He concluded that Chapalote and the allied race Reventador probably represent the maximum introgression of teosinte into maize, and in this connection reported finding large chromosome knobs on all but one of the chromosomes of Chapalote. It is true that relatively high knob numbers are sometimes found in this variety, but the average number in our cultures is 6. The fact that the number is even this high may be the result of interplanting Chapalote and teosinte in the same field, a practice reported by Lumholtz (1902). Much lower numbers would undoubtedly be found in some of the inbred strains of Chapalote.

Because of its primitive nature in general and in spite of its relatively high knob number, we conclude that Chapalote is one of the ancient races of Mexico, and the progenitor rather than the derivative of Reventador. The archaeological remains reported by Anderson (1944a) which he regarded as belonging to Reventador or to some closely related small-cobbed variety are probably remains of ears of Chapalote. Also akin to Chapalote are the ears illustrated by Anderson (1947a) from Painted Cave. Some of the impressions in the lava block in the Morelia Museum might have been made by ears of Chapalote. Finally, the ears of prehistoric maize from Cottonwood Cave in Colorado, described by Hurst and Anderson (1949), are not too far removed from Chapalote. There seems little reason to doubt that Chapalote is an ancient race and one of the direct descendants of the primitive pod-pop corn which must once have occurred widely in Mexico and throughout parts of the Southwest.

Chapalote is undoubtedly closely related to Nal-Tel, the primitive race from Yucatán and Campeche, although widely separated from it geographically. The diagrammatic cross sections of the ears of the two races are almost identical (Fig. 15). Both races have extremely long glumes in relation to kernel length, long rachillae and prominent rachis flaps. Both lack pedicel hairs. Both races have short, early maturing plants with glabrous or near-glabrous leaf sheaths.

Chapalote is also, as already indicated above, closely related to Reventador which is probably derived from it through contamination with teosinte. In addition Chapalote has, through Reventador, left its mark upon a number of more modern races including Tabloncillo, Jala, Celaya and Cónico Norteño.

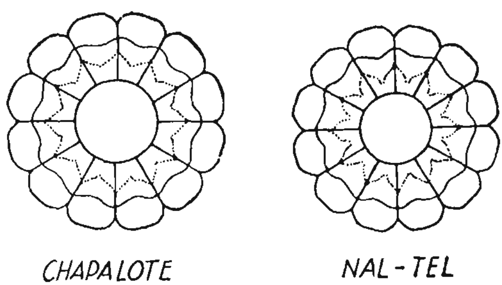


FIG. 15. A comparison of the diagrammatic ear cross sections of Chapalote and Nal-Tel.

Derivation of Name. Name used by people of the region where this race was found. Derivation unknown.

References. Hurst and Anderson, 1949; Chávez, 1913; Kuleshov, 1930; Anderson, 1944a, 1946a; Mangelsdorf, 1948; Mangelsdorf and Smith, 1949.

NAL-TEL

Plants. Short, approximately 1.5 to 2 meters in height in its native habitat; early maturing; tillers none to very few; average number leaves 12; venation index medium; slight plant color and pubescence; highly susceptible to races of rust in central high plateau of Mexico. Average number of knobs 5.5. Best adapted to low elevations.

Tassels. Short with numerous branches arising in a fairly long space on the main axis; secondary branches very numerous, tertiaries infrequent; condensation index lowest of races.

Ears, External Characters. (Fig. 16) Extremely short and small with slight taper at both base and tip; average number of rows

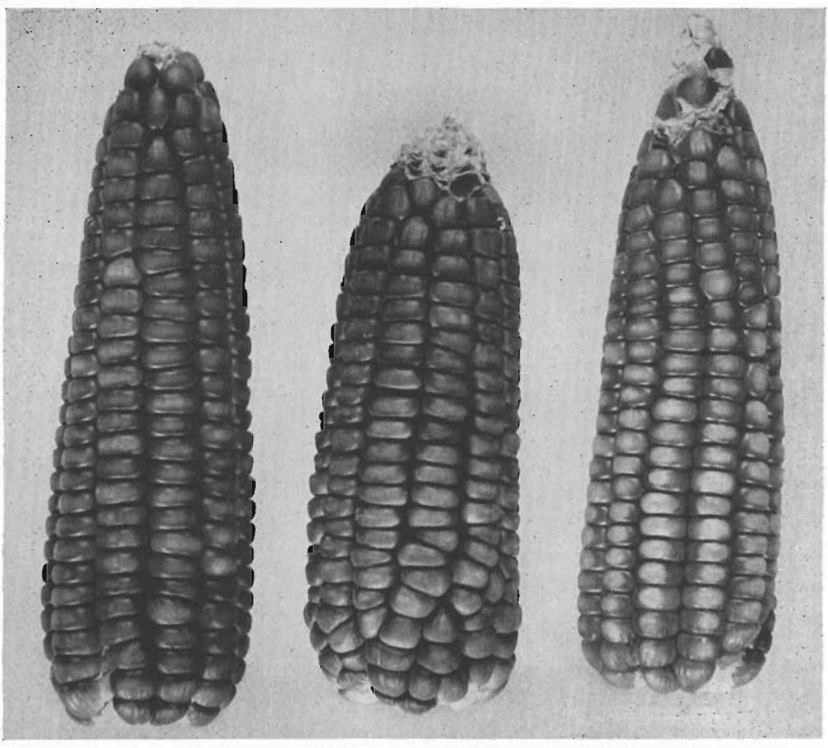


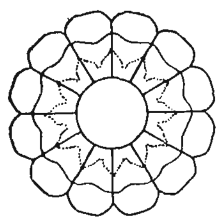
FIG. 16. Nal-Tel, a primitive race of pop corn that can still be found as a relic at low elevations in the Yucatán Peninsula. The plants are very early and small. The ears are very small with a slender rachis, small hard flinty seeds with marked husk striations, and long glumes. Scale 1 cm. = 1.17 cm.

11.4; extremely slender shank, mid-cob color absent. Kernels very small, rounded without denting; striations pronounced; endosperm flinty, pop type, yellow; aleurone colorless; pericarp colorless or weakly colored.

Ears, Internal Characters. (Fig. 17) Ear diameter 26–28 mm.; cob diameter 19.2 mm.; rachis diameter 8–11 mm.; kernel length 7–8 mm.; estimated rachilla length 1.6 mm.; cob/rachis index high.

2.09; glume/kernel index high, 0.68; rachilla/kernel index medium, 0.22; pedicel hairs none; cupule hairs mostly few and short; rachis flap intermediate to strong; lower glumes fleshy, surface hairs many short, marginal hairs few long, margin shape broadly angulate or luniform; upper glumes chaffy, venation weak, shape intermediate to stiff, surface hairs numerous, marginal hairs few; tunicate allele tu^{l}; rachis tissue horny; teosinte introgression none or slight.

Distribution. Nal-Tel is best adapted to low elevations, around 100 meters, but produces fairly normal ears up to 1,800 meters. It has been found principally in the state of Yucatán. The more



NAL-TEL

FIG. 17.

or less pure varieties are rare but the influence of this race is very strongly evident in most of the varieties of Yucatán and in many of the varieties of Campeche. It has probably persisted longer in this area than in others because of its very early maturity. Yucatán in general is quite arid and a corn that will mature on a couple of good rains is considered very valuable. Nal-Tel is probably not as drought-resistant as it is drought-escaping. Varieties very similar to this race have been found in the Pacific coastal plain area north of Pochutla, Oaxaca, and in Zacualpa, Guerrero. Recently Dr. Isabel Kelley of the Smithsonian Institution, working in Mexico, brought in some ears from the Huasteca in the Gulf coastal plain close to Taman, San Luis Potosí, which were practically identical with ears of Nal-Tel collected in Yucatán. Samples most representative of this race in Yucatán were collected from Muna, Hunucma, Becanchen, Oxkutzcab and Ticul. The distribution of Nal-Tel is shown in Fig. 10.

This primitive race was probably widely distributed in tropical areas wherever they were inhabited in ancient times on both the east and west coasts of Mexico. Its influence is not only evident in many of the present varieties in Yucatán and Campeche, but can also be seen in many of the early maturing varieties of Veracruz, Oaxaca, Guerrero and Michoacán at elevations from sea level to 1,800 meters. Its influence is also strongly evident in the early yellow varieties in Cuba. Nal-Tel is represented on an ancient piece of pottery in Guatemala illustrated by Kidder and reproduced with his permission in Plate I, D. Other representations of ears resembling Nal-Tel are found on prehistoric Zapotec funeral urns illustrated in Figure 2 and in Plate I, B.

Origin and Relationships. Nal-Tel is primitive in having a slender rachis, small hard flinty seeds, long glumes and marked striations on the kernel. It is also, in the regions where it is grown, relatively early in maturity which is unusual in a lowland maize. The characteristic of early maturity has been transmitted in varying degrees by Nal-Tel to its derivative races, Zapalote Chico, Bolita, Zapalote Grande and Vandeño. The first two are quite early for tropical corns and the last two are earlier than might be expected from a consideration of their ancestry. Vandeño, for example, is definitely earlier than its east-coast counterpart Tuxpeño, and the difference is largely attributable to the genes which Vandeño has received from Nal-Tel.

Although in some respects different from Chapalote, especially in the shape of the ear, Nal-Tel shows definite relationship to this race, as has already been emphasized in the discussion of Chapalote. Nal-Tel and the closely-allied race Chapalote represent a complex of primitive pop-pod corns which is the lowland counterpart of the Palomero Toluqueño-Arrocillo Amarillo complex found at high altitudes. This complex has not only given rise to the large number of present day races which have already been mentioned but it has had and is still having a strong influence upon the maize of western and southern Mexico. In Yucatán, for example, the introgression of Nal-Tel into Olotillo has not only produced a large number of intermediate forms but it has also given rise to a new sub-race of Olotillo, called Dzit-Bacal, which has a very slender and flexible rachis. Similarly in the state of Guerrero, the early maturing race Conejo, described briefly later under poorly defined races, undoubtedly represents the influence of either Nal-Tel or Chapalote. Finally we find Nal-Tel affecting the tropical flint corns of Guatemala, Cuba, and perhaps other parts of the Caribbean. Nal-Tel is without doubt one of the progenitors of the cylindrical dents as shown by the segregates obtained from them upon inbreeding. (Fig. 98).

Derivation of Name. Nal-Tel is the name commonly used to designate this race in the Yucatán Peninsula. It is of Mayan origin, the word "nal" meaning ear of corn and "tel" meaning rooster. Since the rooster is an early riser, the word "tel" was probably used to indicate the early maturity of this corn.

References. Chávez, 1913; Anderson and Cutler, 1942 (as Guatemalan Tropical Flint); Pérez Toro, 1942; Souza Novelo, 1948.

PRE-COLUMBIAN EXOTIC RACES

Pre-Columbian Exotic races are believed to have been introduced into Mexico from Central or South America in prehistoric times. Four of these, Cacahuacintle, Harinoso de Ocho, Olotón, and Maíz Dulce are recognized. The evidence for their exoticism and antiquity derives principally from two sources. All have South American counterparts and all except Maíz Dulce have been parents of hybrid races, some of which are themselves relatively ancient.

The race designated as Cacahuacintle is a good example to illustrate the kind of evidence upon which this group is based. Cacahuacintle, a large-seeded, white flour corn is found only in a few localities in Mexico, Tlaxcala and Puebla. In its ear characteristics it resembles very closely a variety in Guatemala known as Salpor. Ears of Salpor in turn can be almost exactly duplicated by ears occurring in Colombian collections. In short, there is a continuous series of large-grained flour corns of the Salpor-Cacahuacintle type occurring from Colombia to Mexico. Since the center of diversity of this type of corn is definitely in South America, it is reasonable to conclude that this maize is exotic to Mexico. Evidence for the antiquity of Cacahuacintle in Mexico lies in the fact that it is undoubtedly one of the parents of the race Cónico, which is the predominating type in the Mexican

Plateau. Since Cónico was already well established at the time of the Conquest and since prehistoric remains of it are known, it follows that Cacahuacintle must have been introduced into Mexico in pre-Columbian times. The evidence that the remaining three races in this group are both exotic and ancient will be treated separately in a discussion of their origins. Descriptions, distributions and discussions of the origin and relationship of each race of the Pre-Columbian Exotic group follow:

CACAHUACINTLE

Plants. Medium height, slightly less than 2 meters; early maturing; few tillers; few leaves of medium width and length, venation index 3.16; strongly colored and pubescent; strong tendency to lodge due to poorly developed root system; highly resistant to races of rust in central plateau of Mexico; knob number very low, average 3.0. Adapted to high elevations, 2,200 – 2,800 meters.

Tassels. Short, sparsely branched, average number 5.6, few secondaries, tertiaries infrequent; thickened central spike; condensation index medium high.

Ears, External Characters. (Fig. 18) Medium long, broad at mid-point in length with gradual taper to tip; average number of rows 15.2; shank diameter medium small. Kernels medium to long, rounded, smooth, striations slight; endosperm white, soft, floury; aleurone colorless with inhibitor gene common; pericarp colorless. One of the outstanding ear characters of Cacahuacintle is the complete covering of the base of the ear by the kernels, which is very striking in some of the elote varieties of the central plateau (Fig. 39).

Ears, Internal Characters. (Fig. 19) Ear diameter 43–53 mm.; cob diameter 24–31 mm.; rachis diameter 10–14 mm.; kernel length 13–15 mm.; estimated rachilla length 3.6 mm.; cob/rachis index highest of all races, 2.37; glume/kernel index medium, 0.57; rachilla/kernel index high, 0.26; pedicel hairs many long, prominent; cupule hairs numerous, often long; rachis flap very prominent; lower glumes chaffy to fleshy with transparent margins, surface hairs many, long, marginal hairs few, long, margin shape cordate; upper glumes chaffy with transparent margins, venation

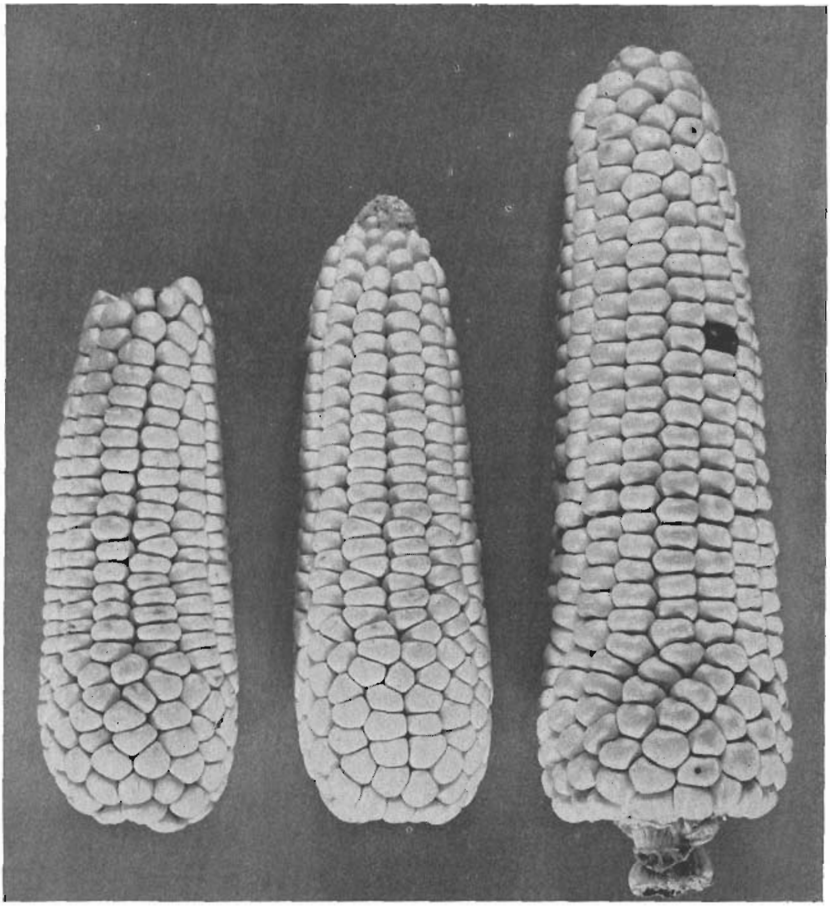
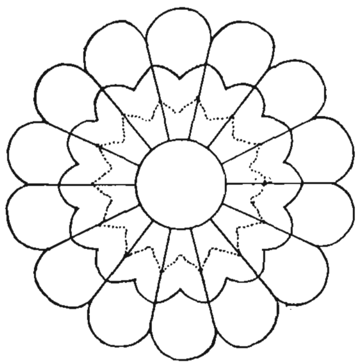


FIG. 18. Cacahuacintle and Salpor. The Mexican race of flour corn, Cacahuacintle, (ears 1 and 2) is very similar to the Salpor race of flour corn from Guatemala (ear 3 right). Cacahuacintle is grown to a limited extent in the high plateau of Central Mexico in approximately the same region as Palomero Toluqueño. Scale 1 cm. = 2.04 cm.

strong, wrinkled, surface hairs profuse, long, marginal hairs few; tunicate allele tu^{w}; rachis tissue usually spongy occasionally slightly horny; teosinte introgression none.

Distribution. Cacahuacintle is limited to altitudes of 2,200 to 2,800 meters in the Central Mesa. Collections have been made in or near the following villages, as shown in Fig. 20: Toluca, San Andrés Ocotlán, San Mateo Atenco in the state of Mexico; Otlatlan, Tezuitlan, Chapulco, San Miguel and Totaltepec in the state of Puebla; and Amaxac de Guerrero, Tlaxcala. It is found in the same area with Palomero Toluqueño and Arrocillo Amarillo. Although no longer very prevalent as a pure race, its influence is strongly evident in the *elote* varieties of the Central Plateau (Fig. 37). Elote varieties are those grown for eating in the milk or soft dough stage, commonly called roasting ears, green corn, or corn-on-the-cob in the United States.



CACAHUACINTLE

FIG. 19.

Origin and Relationships. Cacahuacintle is almost certainly an introduction into Mexico from the south. It resembles the large-seeded flour corn, Salpor, of Guatemala both in external and internal characteristics of the ear. However, in plant characters it is now, at least, quite similar to Palomero Toluqueño. The relationship between Cacahuacintle and Salpor was recognized by Anderson (1946a) who regards Cacahuacintle as having been introduced into Mexico from Guatemala in pre-Columbian times. Ears of Guatemalan Salpor have almost exact counterparts in the flour corn of Colombia which resembles Salpor and Cacahuacintle not only in its ears and kernels but also in its highly colored and hairy leaf sheaths. There is little doubt that Cacahuacintle is a race, only slightly modified, of a distinctive flour corn introduced into Mexico in ancient times. Indirect evidence of its antiquity comes from the primary and secondary derivative races which it has sired including Cónico, Chalqueño and Cónico Norteño, one

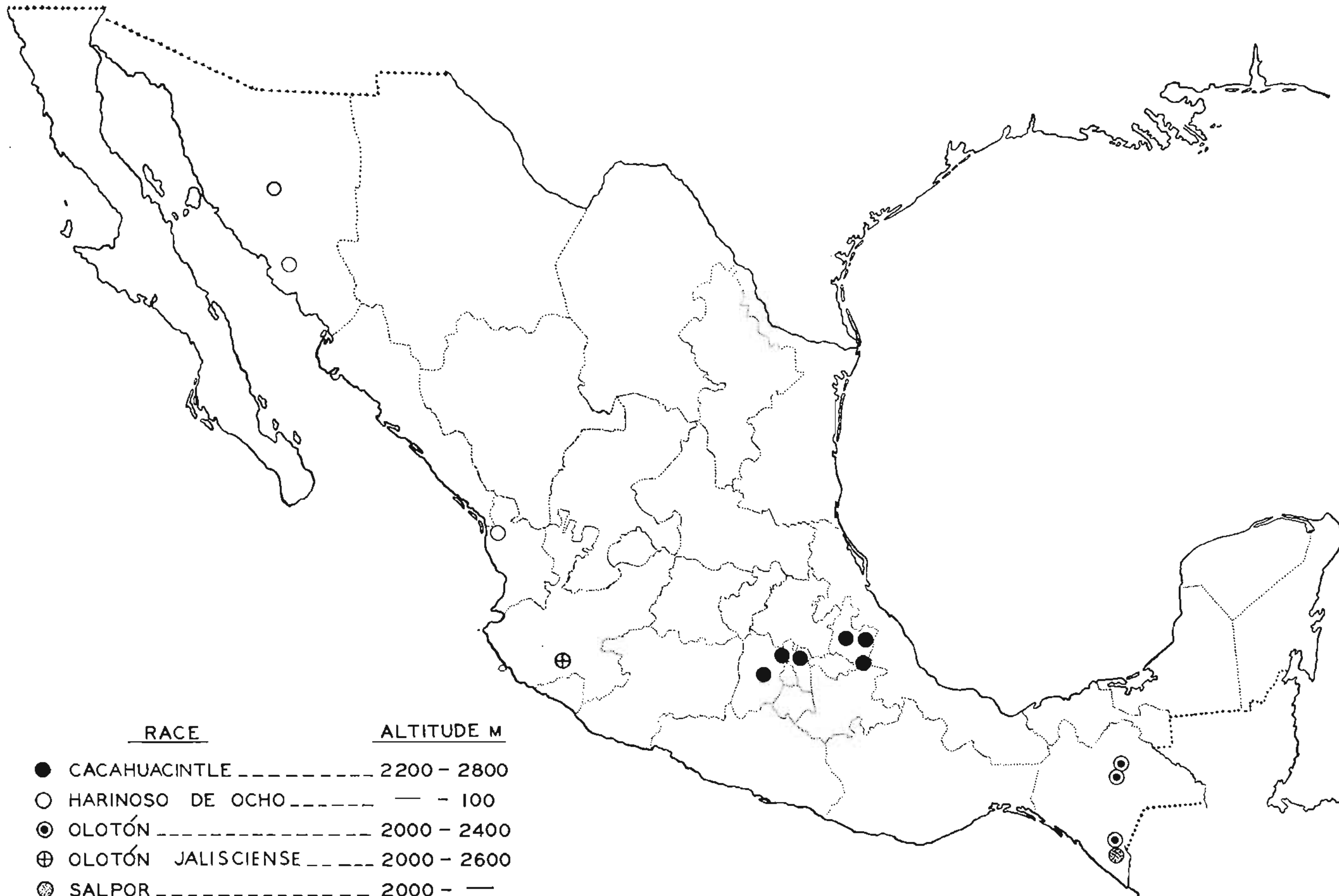


FIG. 20. Distribution of Cacahuacintle, Harinoso de Ocho, Olotón, Olotón Jalisciense and Salpor.

of which, Cónico, is found in prehistoric remains and lava rock impressions (Fig. 4). Cacahuacintle is used primarily as an elote, or roasting ear corn, and is preferred for this purpose to other varieties grown in the Central Plateau. It is evidently a relict of a complex of flour corns brought in from the south which were once more widely distributed than now. Other relicts of this complex are the colored Cónico-type elote corns described later. These have been selected for colored aleurone, colored pericarp and floury endosperm. Associated with this group of independently inherited characters is the well covered base of the ear so characteristic of many ears of Cacahuacintle.

Derivation of Name. Cacahuacintle is the name used in the regions where this kind of corn has been found. Its derivation is not known definitely but according to Siméon (1885) the word "cacahuacentli" (cacauacentli) probably comes from two Nahuatl words "cacauatl" meaning cacao and "cintli" meaning maize, i.e. "maize with cacao-like kernels".

References. Siméon, 1885; Kuleshov, 1930; Mangelsdorf and Cameron, 1942 (Salpor); Anderson, 1946a; Lenz, 1948; Bautista R., 1949.

HARINOSO DE OCHO

Plants. Glabrous, colorless with medium wide leaves, medium length tassels and long cylindrical eight-rowed ears; leaves with one of the lowest venation indices of all races; leaf sheaths glabrous and without sun-red color; high resistance to races of rust present in north central plateau of Mexico. Adapted to low elevations, about 100 meters.

Tassels. Medium length with few branches; tassel branches 10 per tassel, arising from one-fourth of the length of the central spike; secondaries 12.0%, tertiaries absent.

Ears, External Characters. (Fig. 21) Long, medium diameter, cylindrical, usually eight-rowed, slight taper at both ends; shank diameter large; mid-cob color absent. Kernels large, flat, broad, rounded, smooth; striations marked; endosperm white, soft, floury; aleurone colorless, pericarp usually colorless.

Ears, Internal Characters. (Fig. 22) Ear diameter 37–39 mm.; cob diameter 19–24 mm.; rachis diameter 9–12 mm.; kernel

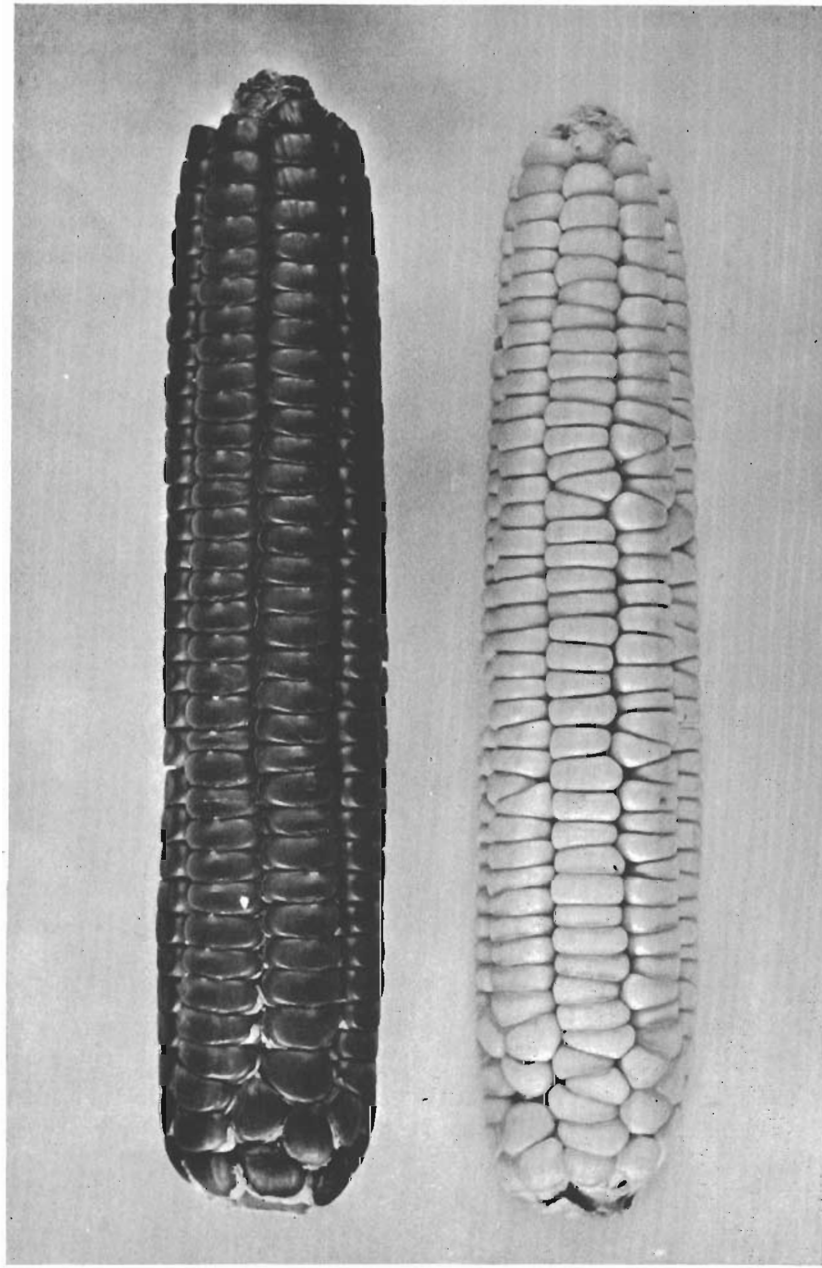
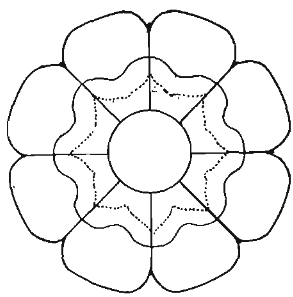


FIG. 21. Harinoso de Ocho, a race of flour corn that is found only occasionally in the northwestern part of Mexico. The slender, eight-rowed ear and the broad, soft kernels are characteristics found also in the Guarani corn of Paraguay and the Indian flour of the Northern Great Plains in the U.S.A. Scale 1 cm. = 1.25 cm.

length 10–12 mm.; estimated rachilla length 2.6 mm.; cob/rachis index high, 2.03; glume/kernel index low, 0.49; rachilla/kernel index medium, 0.23; pedicel hairs few, long; cupule hairs many, long; rachis flap intermediate to prominent; lower glumes fleshy, surface hairs few long, marginal hairs many long, margin shape sinuate to cordate; upper glumes fleshy, stiff, venation none, surface glabrous; tunicate allele *tu*; rachis tissue slightly horny; teosinte introgression intermediate.



HARINOSO DE OCHO

FIG. 22.

Distribution. Harinoso de Ocho has been found in more or less pure form only in three places on the west coast at 100 meters elevation; namely, El Yaqui valley and Ures in Sonora, and Ejido San Vicente in northern Nayarit (Fig. 20). Samples less pure were collected from the Ejidos Milpas Viejas, Quimichis and Palma Grande in Nayarit. It is best adapted to the dry tropics and although no longer very prevalent in its original form, its counterparts exist in the western Mexico elote varieties. At one time, it may have been widely used throughout western Mexico but now has been largely replaced by Tabloncillo, a race of corn derived from it.

Origin and Relationships. Harinoso de Ocho shows certain resemblances to the Guarani corn of Paraguay on the one hand and to the eight-rowed Indian flour corn of the Northern Great Plains of the United States on the other. It appears to be even more closely related to the prehistoric flour corn of Cañon del Muerto described by Anderson and Blanchard (1942) estimated to be at least 1,000 years old, and probably has affinities with Papago white flour corn illustrated by Carter and Anderson (1945) which is regarded by these authors as an introduction into the southwestern United States from Mexico. One of the ears in the collection belonging to the Instituto de Investigacciones Agrícola S. A. G., in Mexico, is almost identical in its marked striations and in the tesselation of the kernels in alternate rows with an ear of Papago flour corn illustrated by Carter and Anderson. We regard Harinoso de Ocho in Mexico as a relict of a large-seeded, few-rowed flour corn originally introduced from South America, the apparent center of flour corn, and once widely distributed in western and northwestern Mexico, but now largely replaced by its derivatives.

Harinoso de Ocho has given rise directly to the widely grown Tabloncillo and indirectly to Jala, Bolita, Celaya and Cónico Norteño. It is related to Olotillo of southwestern Mexico and even more closely related to Harinoso Flexible, the putative parent of Olotillo. The resemblance of Harinoso de Ocho to Tabloncillo and Olotillo is demonstrated by the diagrammatic cross sections in Plates III and V.

Derivation of Name. The word "harinoso" means floury and refers to the soft floury texture of the grain; "ocho" means eight and refers to the eight rows of grain typical of this race. Since the most outstanding characters of the ears of this race are the floury grain texture and eight rows of kernels, the name "Harinoso de Ocho" was selected as appropriate.

References. Anderson and Blanchard, 1942; Anderson and Cutler, 1942 (Pima-Papago); Carter and Anderson, 1945 (Pima-Papago).

Sub-race of Harinoso de Ocho
Elotes Occidentales

Closely related to Harinoso de Ocho and at the present time much more frequently collected in western Mexico are the colored elote or roasting ear corns illustrated in Fig. 23. Since it is doubtful that aleurone color or pericarp color either alone or in combination have any appreciable effect upon flavor, the widespread preference of colored corns for roasting ears must have some other reason. The basis for the preference may well lie in the fact that flour corns are definitely superior to dent corns for roasting ears. Both aleurone and pericarp colors are usually more intense in flour corns than in dent corns. Selection for intensely

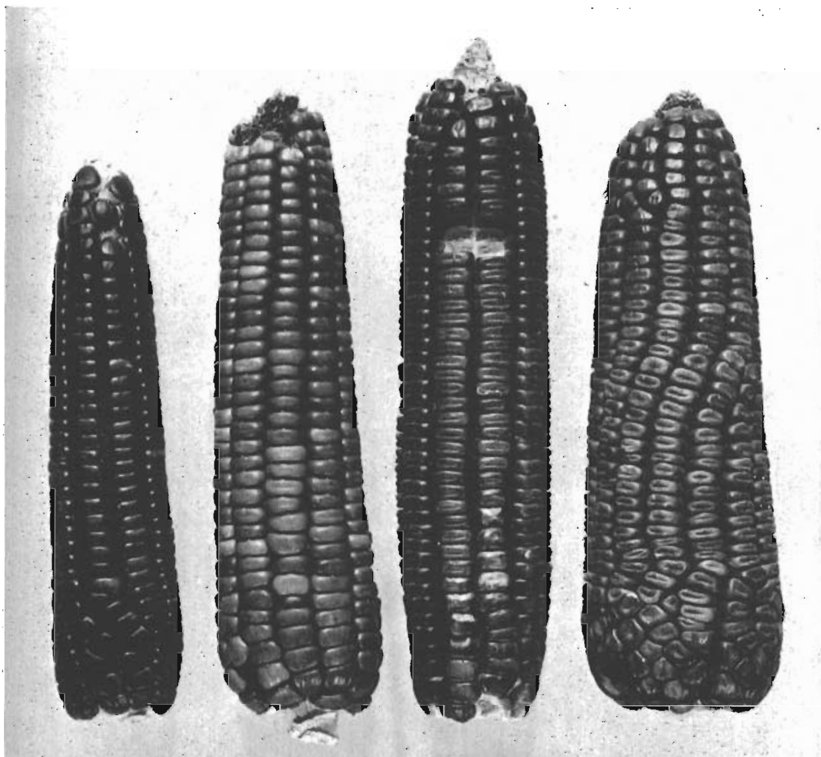


FIG. 23. Western Elote Corns. Variation in the colored elote corns of Western Mexico, which are considered as a sub-race of Harinoso de Ocho. The increased variability in the elote corns probably comes from an admixture with other races, principally Tabloncillo and Cónico. Scale 1 cm. = 2.34 cm.

colored ears thus tends to keep a race pure for the gene for floury endosperm.

The center of distribution of the varieties most typical of this sub-race or those more nearly like Harinoso de Ocho is in the Jaliscan plateau, ("Altiplanicie de Jalisco") at 1200 to 1600 meters elevation as shown in Fig. 24 by the circles with a cross. Varieties in the coastal areas of Nayarit are also quite typical. But to the

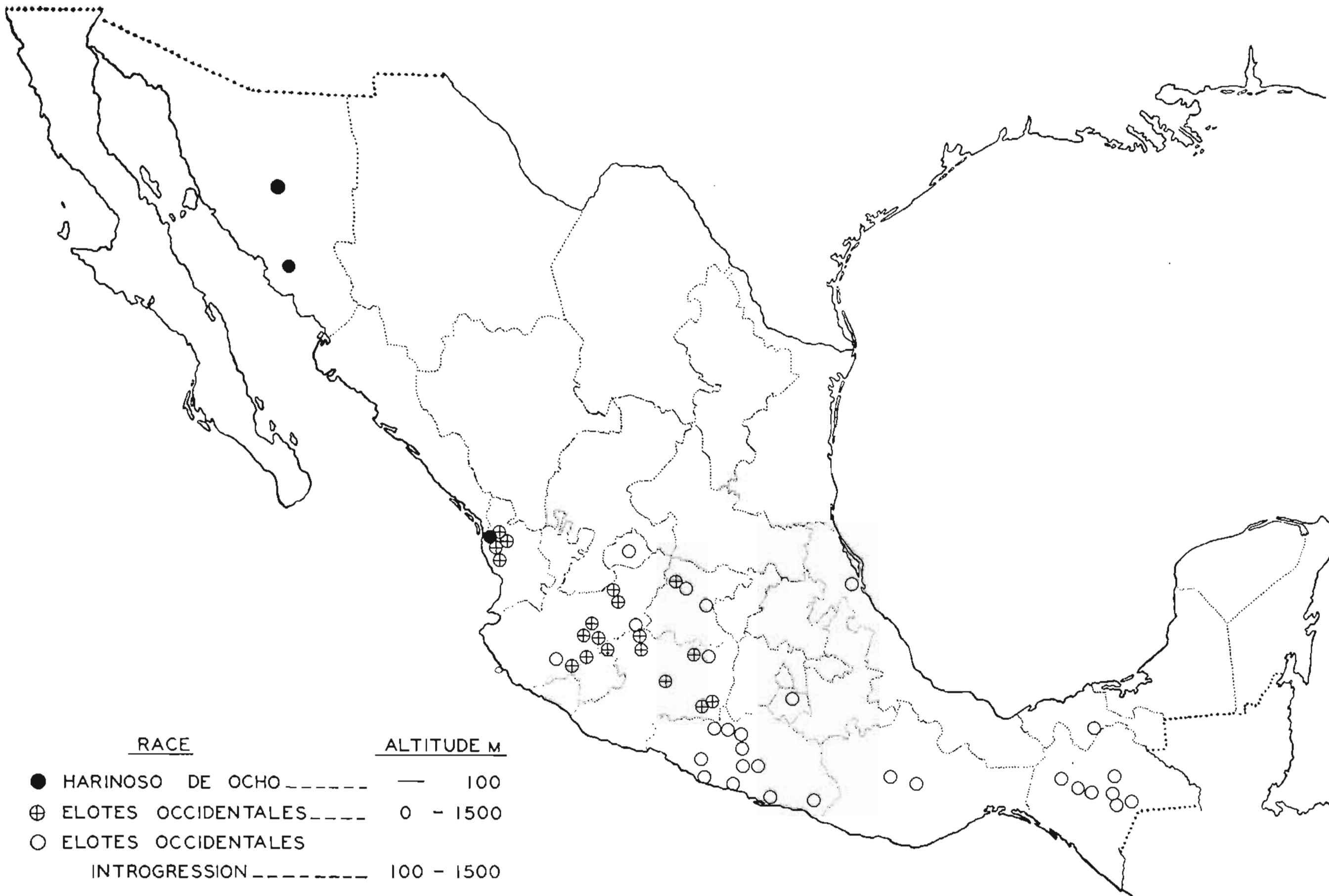


FIG. 24. Distribution of Harinoso de Ocho, Elotes Occidentales and types showing a strong introgression of Elotes Occidentales.

north and east of the Jaliscan plateau at higher elevations the elote varieties show a strong introgression of Cónico. To the south at lower elevations in the Balsas River Basin and coastal plains of the state of Guerrero, and the Grijalva River Basin in Chiapas (white circles Fig. 24) the elote types have lost much of their floury texture and have become greatly modified by the other races common to these regions. The "Elotes Occidentales", therefore, represent the eight-rowed flour corn complex of western Mexico which has become only slightly modified in the Jaliscan plateau and the coastal areas of Nayarit but more strongly modified by the introgression of other races as one moves away from the Jaliscan plateau to the lower elevations on the south or higher elevations on the northeast. In these modified types some of the original characteristics were retained because of selection for aleurone color, pericarp color or both.

OLOTÓN

Plants. Tall, 2.5–3 meters; medium maturity; few tillers; leaves abundant, averaging 16 per plant; venation index medium; medium amount of sun-red color, medium pubescence; highly resistant to races of rust present in central high plateau; knob number low. Adapted to high elevations, 2,000–2,400 meters.

Tassels. Long, medium number branches, average 16.8, secondaries numerous, tertiaries absent; condensation index low.

Ears, External Characters. (Fig. 25) Medium to long; enlarged base common in which number of rows is obscured, apart from enlarged base the rows are distinct though often not straight, averaging 11.7 in number; thick shank; kernels large but short, approaching a semi-spherical shape, rounded and smooth on top surfaces; striations slight, endosperm flinty, white or yellow; segregates for purple, red and colorless aleurone; pericarp usually colorless.

Ears, Internal Characters. (Fig. 26) Ear diameter 40–44 mm.; cob diameter 25–30 mm.; rachis diameter 10–18 mm.; kernel length 10–12 mm.; estimated rachilla length 3.0 mm.; cob/rachis index medium, 1.94; glume/kernel index medium to high, 0.60; rachilla/kernel index high, 0.27; pedicel hairs intermediate in number and length; cupule hairs few, variable in length; rachis

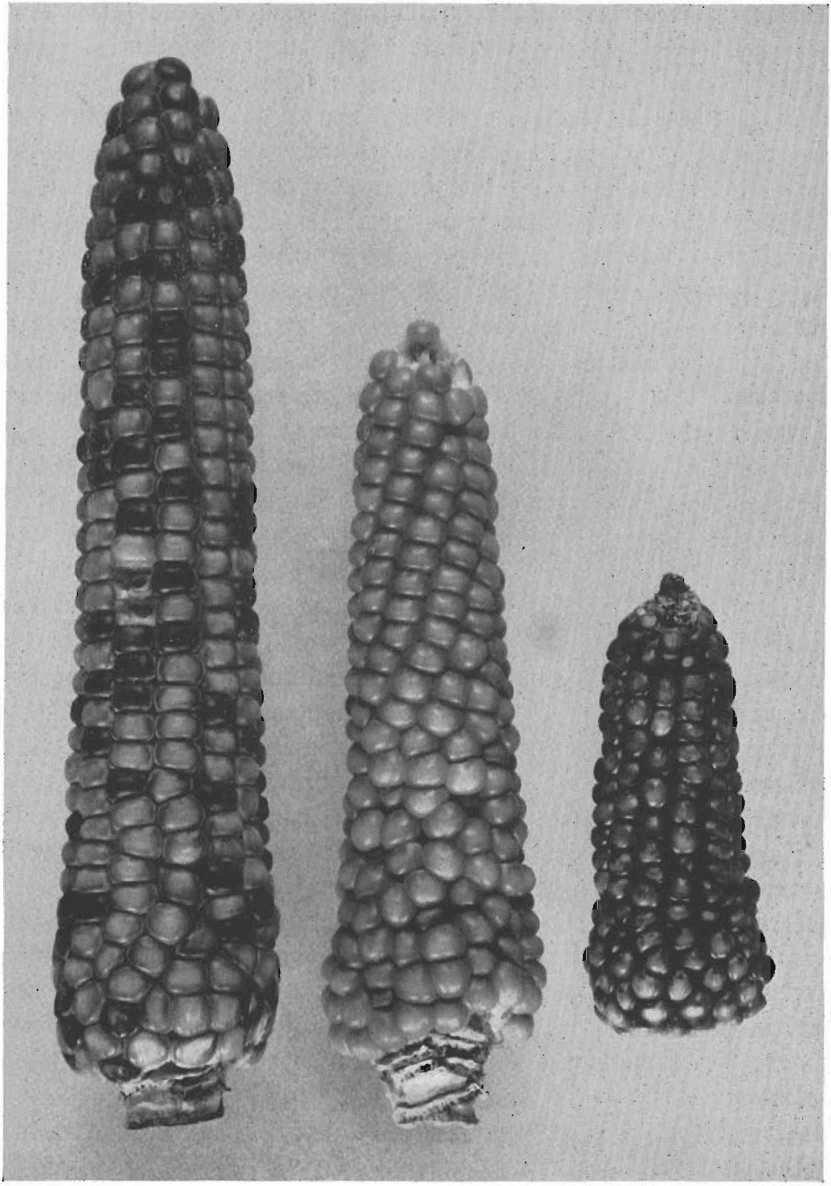
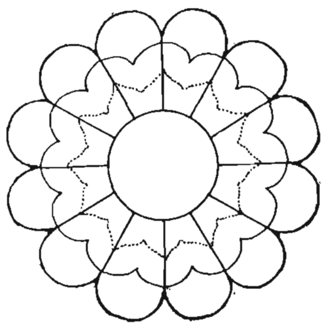


FIG. 25. Oloton, a race adapted to high altitudes in Southern Mexico, especially Chiapas. This is primarily a Guatemalan race that has been introduced into Mexico. The most distinctive feature is the ear with the large round flinty seeds in irregular rows on a thick rachis with an enlarged base. Ear on right is from Jalisco and shows introgression of Oloton into the corns of the Jaliscan mountains.
Scale 1 cm. = 1.87 cm.

flap weak to prominent; lower glumes fleshy to horny, surface hairs few, marginal hairs many long, margin shape broadly angulate to cordate; upper glumes fleshy, venation none, stiff, basal hairs few long, marginal hairs few long; tunicate allele tu^w; rachis tissue horny; teosinte introgression intermediate.

Distribution. Olotón is not very prevalent in Mexico. Collections of the purer forms were made in Chiapas at San Vicente Lagarnacha, San Cristobal, Las Casas, Cerro Male and Bejucal de Ocampo (Fig. 20). It is more prevalent in the adjacent highlands of Guatemala. The only other place where evidence of the



OLOTON
FIG. 26.

existence of this race has been found is in Cerro de Lempoala, Oaxaca and in the mountain range of southern Jalisco, extending northward from the Volcan de Colima to Juanacatlan, at elevations of 2,600 meters and above. It has left its mark on the modern incipient races in this region and, to a lesser extent, on the Cónico maize of Michoacán.

Origin and Relationships. Olotón was undoubtedly introduced into Mexico from Guatemala; and this large-grained type of flint corn in Guatemala is in turn closely related to similar types which are widespread in Colombia. There seems little doubt, therefore, that Olotón was originally a South American introduction. Indirect evidence that this introduction was pre-Columbian lies in the fact that Olotón is the putative ancestor of several well-established existing races. Olotón appears to be one of the parents of Comiteco from which the secondary race, Jala, has been derived through hybridization with Tabloncillo. Since time must be allowed for the development of this race we conclude that Olotón must have been a pre-Columbian introduction.

It appears that Olotón has also been an important factor in the development of the variety complex in the mountains of southern Jalisco. The type described by Anderson (1946a) as "Mountain

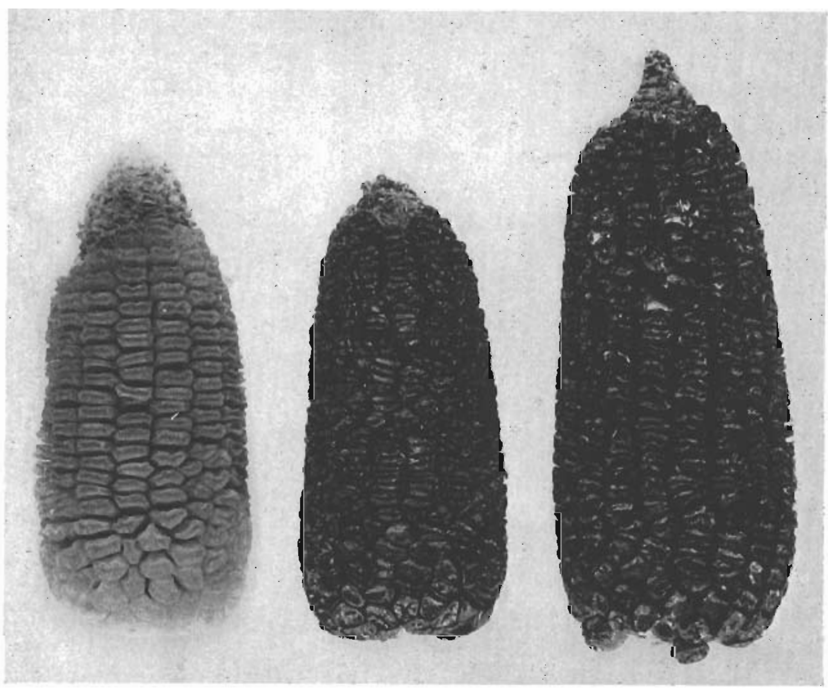


FIG. 27. Maíz Dulce, a race of sweet corn found principally in the state of Jalisco. The characters of this race differ from any other race found in Mexico and evidence of its influence on other races is extremely meager. Scale 1 cm. = 1.83 cm.

Yellow" probably originated as a cross between Palomero Toluqueño and Olotón with perhaps some introgression of Tabloncillo. Varieties existing in the high altitude areas of southern Jalisco and in Colima are quite variable and need further study before the racial situation can be clarified. In general they seem to be a mixture of Palomero Toluqueño, Olotón and possibly Tabloncillo. Ears very similar to Olotón in shape and type of grain, like the one shown at the right in Fig. 25, often can be found in some varieties of the high altitude areas of southern Jalisco. This type of corn found in the mountain area of southern Jalisco will be discussed further as "Complejo Serrano de Jalisco" in the section on poorly defined races.

Derivation of Name. Olote in Mexico is the word used for cob. A variety of corn with a thick cob is often referred to as Olotón. Since one of the outstanding characters of this race is its relatively thick cob in relation to depth of grain, the name Olotón was selected.

References. Anderson and Cutler, 1942 (as Guatemalan Big Grain); Mangelsdorf and Cameron, 1942 (as Andean); Anderson, 1947b; Cuevas Ríos, 1947 (as Guatemalan Big Butt).

MAÍZ DULCE

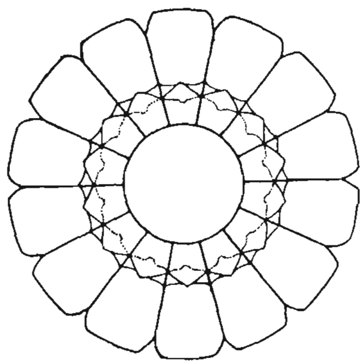
Plants. Medium height; early maturing; tillers profuse; medium number of leaves with medium width and length; venation index very high; color and pubescence very slight; moderately susceptible to races of rust present in central plateau of Mexico; number of knobs low, average 5. Adapted to intermediate elevations, 1,000–1,500 meters.

Tassels. Long, medium number of branches arising in one-fourth the length of central axis; secondaries common; tertiaries absent; medium high condensation index.

Ears, External Characters. (Fig. 27) Short, broad, cylindrical, slightly tapering at both ends; 14–16 rows; small to medium shank; mid-cob color in 50% of ears; kernels medium wide, medium long, thin, square at top with wrinkled cap; endosperm sugary, white or yellow; pericarp colorless or red.

Ears, Internal Characters. (Fig. 28) Ear diameter 44–48 mm.; cob diameter 24–28 mm.; rachis diameter 15–17 mm.; kernel length 11–13 mm.; estimated rachilla length 2.8 mm.; cob/rachis index low, 1.68; glume/kernel index low, 0.43; rachilla/kernel index medium, 0.23; pedicel hairs none; cupule hairs many of intermediate length; rachis flap intermediate; lower glumes fleshy to slightly horny, marginal hairs few long, margin shape cordate with a few long hairs arising from the notch; upper glumes with a very distinctive pattern, the fleshy tissue coming to a point terminated by a tuft of hairs, the remainder of the glume more or less transparent, venation none, shape wrinkled to intermediate; tunicate allele *tu*; rachis tissue horny; teosinte introgression intermediate to strong.

Distribution. Maíz Dulce has been found mainly in the state of Jalisco at elevations of 1,000 to 1,500 meters (Fig. 29). Collections reported by Kelly and Anderson (1943) are mainly from southwestern Jalisco. Those made by the Oficina de Estudios



MAIZ DULCE

Fig. 28.

Especiales, S. A. G., show its range into northern Jalisco, Nayarit, northern Michoacán, north central Guanajuato and central Durango. Places at or near which collections were made other than those reported by Kelly and Anderson are as follows: Tangancicuaro, Michoacán; Atoyac and Yahualica, Jalisco; Comomfort and Irapuato, Guanajuato; Los Patos, Durango; and Ejidos Chilapa and Palma Grande in Nayarit. Although the race seems to be best adapted to the intermediate elevations of western Mexico, certain modifications of it have been collected at elevations of 100 meters in Nayarit and Sonora (cf, section on poorly defined races). It is grown on a limited scale for the special uses mentioned above.

Origin and Relationships. Maíz Dulce is recognized in Mexico as an ancient type of maize with a long tradition of special uses. Kelly and Anderson regard it as having affinities with the sweet corn of South America. Since there is no known maize in Mexico from which it could have been derived through mutation, and

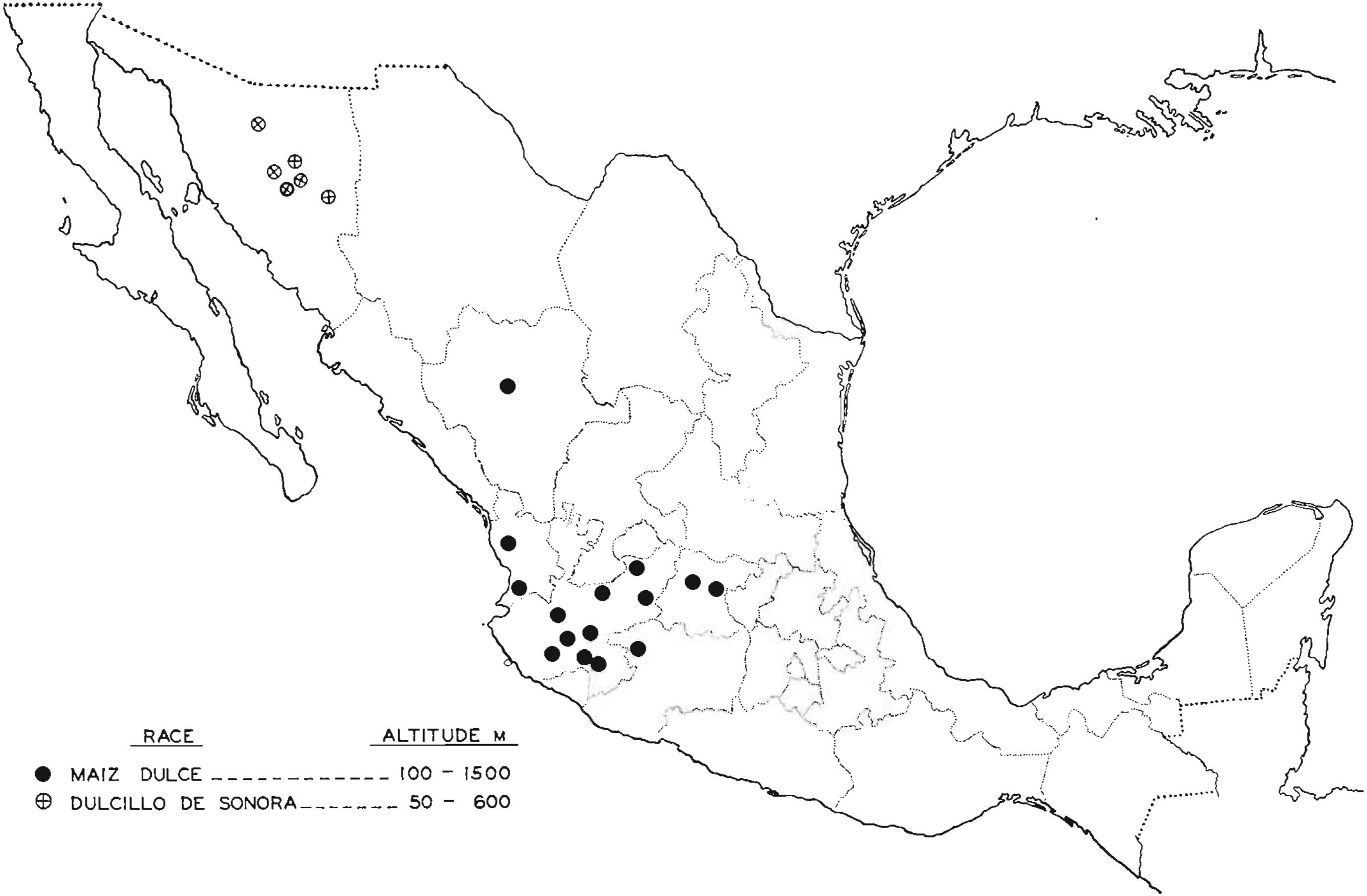


Fig. 29. Distribution of Maíz Dulce and Dulcillo de Sonora.

since it does resemble the sweet corn of South America (Cutler, 1946) in its large-cobbed many-rowed ears, we are inclined to agree with their conclusion. There is no direct evidence, archaeological or otherwise, of the antiquity of Maíz Dulce in Mexico and it has not, so far as we can determine, been the progenitor of any secondary hybrid races with the possible exception of the sweet corn found in Sonora, which needs further study. Our conclusion that it is pre-Columbian is, therefore, based largely on the fact that it is South American in its affinities, that it has a tradition of antiquity in parts of Mexico where it is grown, and that it resembles in internal characters of the ear the other Pre-Columbian Exotic races for which there is evidence of antiquity.

Ears segregating for sugary endosperm are sometimes found in both Reventador and Chapalote. These have probably resulted from previous hybridization of these races with Maíz Dulce. We have been told that it is not uncommon for farmers to grow Reventador and Maíz Dulce together in the same field as special crops separated from the principal maize field. This practice has resulted in the introgression of the sugary gene into Reventador and the reciprocal introgression of the gene for pericarp color into Maíz Dulce. The apparent introgression of teosinte into Maíz Dulce (Table 16) may also be attributed to this hybridization. There is no evidence that Maíz Dulce is the progenitor of any of the numerous varieties of sweet corn now grown in the United States.

Derivation of Name. Dulce in Spanish means sweet, hence maíz dulce or sweet corn.

Special Uses. Principally as confections such as (1) "pinole", a sweet powder made from the ground roasted kernels; and (2) "ponteduro", balls made of puffed roasted kernels held together with syrup. Also used in gruels and soups.

References. Kuleshov, 1930; Kelly and Anderson, 1943; Anderson, 1946a.

PREHISTORIC MESTIZOS

Prehistoric Mestizos include races which are believed to have arisen through the hybridization of Ancient Indigenous races with Pre-Columbian Exotic races and through the hybridization of both with a new element, teosinte. We use the term prehistoric rather than pre-Columbian for this group because although all are prehistoric in the sense that there is no historical evidence of their origin, it is not certain that all are pre-Columbian. Several of them may have had their origin as the consequence of the movements of the early colonists. All of them, however, are at least ancient enough to have now reached a rather high degree of genetic stability.

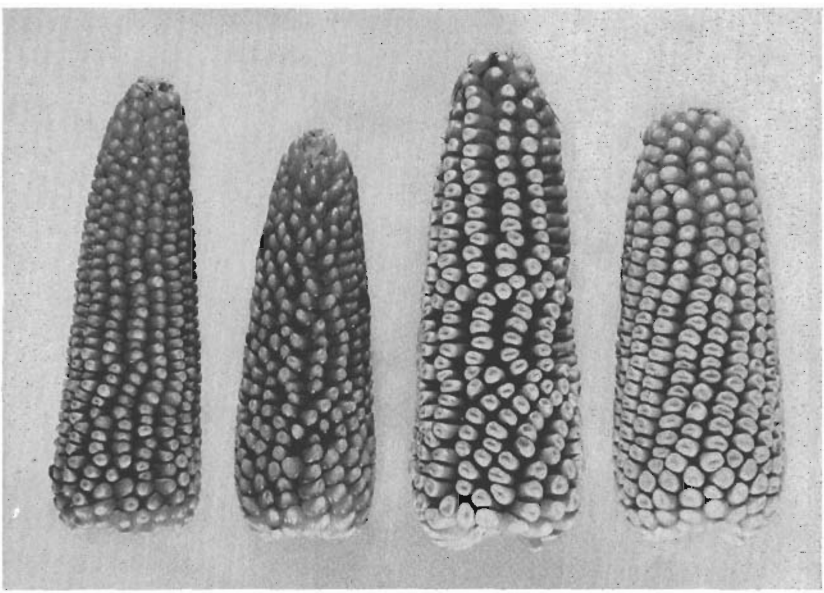


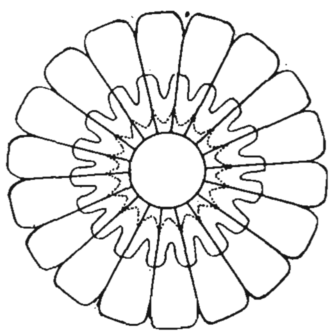
FIG. 30. Cónico. Typical ears from varieties of the Cónico race which is the common agricultural type planted at the beginning of the rainy season in the Central High Plateau. Scale 1 cm. = 2.29 cm.

The number of possible hybrid races which could be derived directly through the hybridization of nine different elements (eight races and teosinte) is thirty-six. So far only thirteen races of this type are recognized. The reason that more have not been formed is because the nine elements have been more or less isolated from each other, not only in latitude and longitude but also in altitude. Ecology in Mexico is a matter not of two dimensions but of three. Races of maize growing not more than a few miles apart but separated by several thousand feet in altitude are as effectively isolated as though by a mountain range arising between them.

Actually, only five of the races included in the group called Prehistoric Mestizos are thought to be the primary products of the intercrossing of more ancient varieties or of the hybridization with teosinte; others are secondary and even tertiary products of racial hybridization, and their pedigrees are exceedingly complex.

CÓNICO

Plants. Short to medium, averaging 1.7 meters; very early; few tillers; poorly developed root system with much lodging; leaves sparse and drooping with coarse, leathery texture, wide in relation to length; strongly colored and pubescent; low venation index; highly resistant to races of rust in central plateau of Mexico; knob number very low. Adapted to high elevations, 2,200–2,800 meters.



CONICO

FIG. 31.

Tassels. Short, very few branches arising in short space on a thick central spike, secondaries few, tertiaries absent; condensation highest of races.

Ears, External Characters. (Fig. 30) Short, conical, acute uniform taper from base to tip; average number of rows 16; small shank; mid-cob color in 39% of ears examined. Kernels medium small, being long in relation to width and thickness, moderately pointed and dented; striations weak to absent; endosperm moderately hard to hard, dirty white; aleurone and pericarp colorless, inhibitor gene for aleurone color common.

Ears, Internal Characters. (Fig. 31) Ear diameter 34–47 mm.; cob diameter 17–21 mm.; rachis diameter 9–10 mm.; kernel

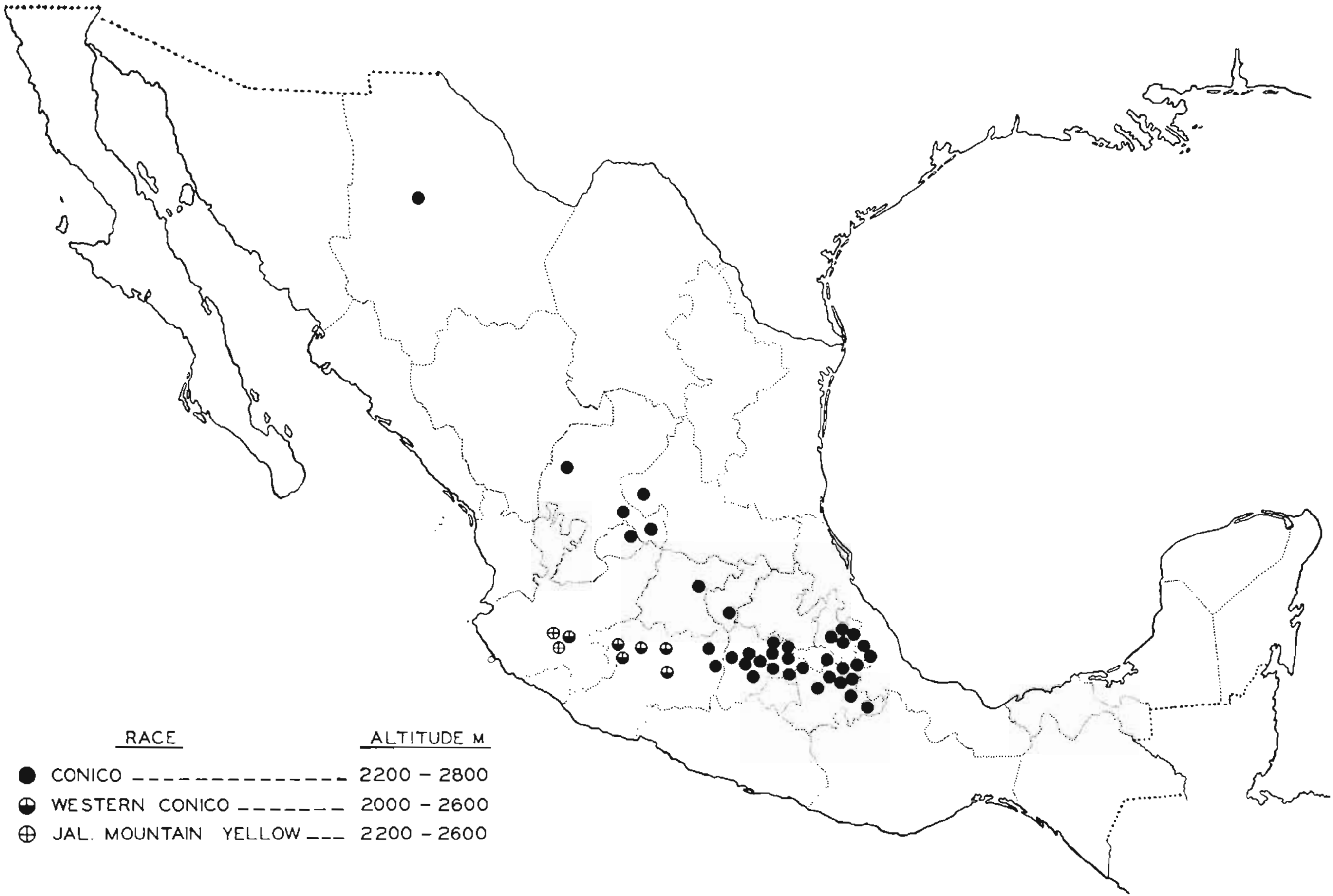


FIG. 32. Distribution of Cónico, Cónico Occidental and Amarillo Serrano Jalisciense.

length 11–16 mm.; estimated rachilla length 1.6 mm.; cob/rachis index medium, 1.98; glume/kernel index low, 0.32; rachilla/kernel index low, 0.11; pedicel hairs intermediate to many; cupule hairs few to many; rachis flap intermediate to prominent; lower glumes fleshy, surface hairs few, marginal hairs intermediate in number and length, margin shape cordate; upper glumes chaffy with chaffy to transparent margins, venation strong, shape wrinkled, surface hairs mainly basal and long, marginal hairs intermediate in number and length; tunicate allele *tu*; rachis tissue spongy; teosinte introgression none.

Distribution. Cónico is the predominating race on the Central Mesa with elevations ranging from 2,200 to 2,800 meters (Fig. 32). It is the chief commercial corn grown in the states of Mexico,

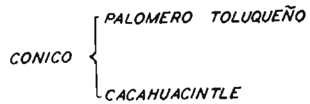


FIG. 33. The origin of Cónico.

Tlaxcala, Puebla and parts of Michoacán and Hidalgo during the rainy season. Its distribution follows the mountain range west through Michoacán into Jalisco and north through Querétaro, Guanajuato and Zacatecas. One sample was collected as far north as Villa Cuauhtemoc, Chihuahua. The western Cónicos show considerable influence of the Jaliscan mountain complex, which in turn is complicated by the ancient introduction of Olotón.

Origin and Relationships. Cónico is undoubtedly a product of the hybridization of Palomero Toluqueño and Cacahuacintle, as diagrammed in Fig. 33. Various degrees of the reciprocal introgression between Palomero Toluqueño and Cacahuacintle are found and are illustrated in Fig. 34. Cónico has its center of distribution in the Central Mesa where both putative parents are still to be found. It resembles one or the other of the two parents, or is intermediate between them in practically all of its characteristics. The intermediate condition of Cónico between Palomero Toluqueño and Cacahuacintle in ear measurements and certain plant characters is clearly evident in Table 1. This intermediacy is shown even more strikingly by the diagrammatic cross sections

TABLE 1. Ear Measurements and Plant Characters of Palomero Toluqueño (Mex. 5), Cacahuacintle (Mex. 7) and Their F_1 Hybrid Compared to Cónico.

	Palomero Toluqueño (Mex. 5)†	*Hybrid (Mex. 5 × Mex. 7)*	*Cónico*	*Cacahuacintle (Mex. 7)*†
Plant Characters				
Pilosity	3	4	3.4	4
Tillering index *	0.26	0.35	0.22	0.39
Height of Plant (cm.)	175	200	193	210
External Ear Characters **				
Mid-ear diam. (mm.)	37.1±1.24	45.2±0.57	45.1±0.48	53.2±1.11
No. of rows	21.8±1.35	18.6±0.90	15.7±0.37	16.2±0.55
Width of kernel (mm.)	4.6±0.11	6.8±0.34	7.4±0.15	9.8±0.19
Thickness of kernel	2.8±0.12	3.6±0.09	3.9±0.07	5.3±0.18
Diam. of peduncle	8.0±0.31	9.2±0.42	9.8±0.30	10.6±0.68
Length of ear (cm.)	9.8±0.7	11.8±0.49	12.6±0.26	14.7±0.85
Internal Ear Characters				
Ear diam. (mm.)	34.0		42.4	47.0
Cob diam. (mm.)	19.5		19.0	27.7
Rachis diam. (mm.)	10.4		9.6	11.7
Length of kernel (mm.)	11.4		14.8	14.0
Length rachilla (mm.)	0.4		1.6	3.6
Cob/rachis Index	1.88		1.98	2.37
Glume/kernel Index	0.40		0.32	0.57
Rachilla/kernel Index	0.04		0.11	0.26
Pedicel Hairs	0		2–4	4
Rachis Flap	0		2–3	3
Rachis Induration	0		0	0–1
Teosinte Introgression	0		0	0

* Tillering index = $\frac{\text{Total no. of tillers}}{\text{Total no. of plants}}$

** Measurements for external characters of the ears of Cónico are based on an average of 5 different samples of 10 ears each, or a total of 50 ears. Measurements for the external characters of the ears of Palomero Toluqueño, Cacahuacintle and the hybrid between them are based on random samples of 25 ears each.

† Mex. 5 and Mex. 7 indicate the collections No's. 5 and 7 obtained in the state of Mexico as recorded in the Registry Book of the Office of Special Studies. The data included in this table are from the collections shown only and do not necessarily agree exactly with the data in subsequent tables based on additional collections.

in Fig. 35. It is also evident to some extent in the internode patterns (Plate VII). Inbreeding of Cónico isolates types which closely resemble Palomero Toluqueño as one extreme and approach but never duplicate Cacahuacintle as the other. Furthermore, a synthetic Cónico has been produced by hybridizing Palomero Toluqueño and Cacahuacintle. The ears of the hybrid (Fig. 36) are practically identical with those of Cónico except that they segregate for endosperm texture. Also as evident in Table 1, the hybrid is very similar to Cónico in its ear measurements and certain plant characters. The evidence of the hybrid origin of Cónico is, therefore, quite conclusive. That it is pre-Columbian in origin is proved by the charred remains at Teotihuacán (Anderson, 1946a) and the impressions in the block of lava in the museum at Morelia (Fig. 4).

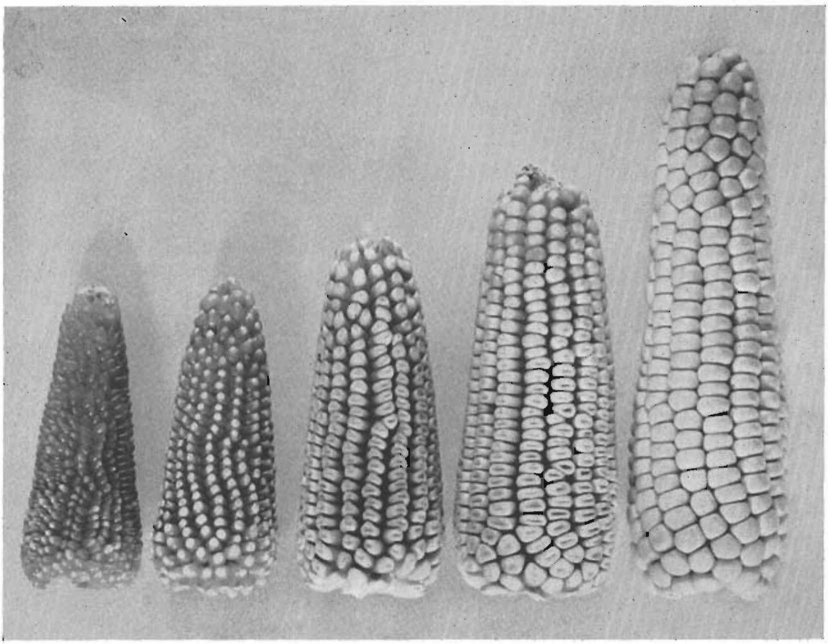


FIG. 34. Introgression involving Palomero Toluqueño and Cacahuacintle, the two putative parents of the Cónico race. Left to right (1) Palomero Toluqueño, (2) Cónico with strong tendencies toward Palomero Toluqueño, (3) typical ear of Cónico more or less intermediate between the two parents and (4) Cónico with strong tendencies toward Cacahuacintle, (5) Cacahuacintle.
Scale 1 cm. = 2.59 cm.

Derivation of Name. The word Cónico means in the form of or resembling a geometrical cone. The name is very appropriate for this race since the most outstanding characteristic of the ears is their conical shape.

References. Sahagún, 1529–1590; Bonafous, 1836; Ramirez, 1903; López y Parra, 1908b; Chávez, 1913; Kuleshov, 1930; Anderson and Cutler, 1942 (as Mexican Pyramidal); Anderson and Finan, 1945; Anderson, 1946a, b, 1947a (as Mexican Pop-dent); Bautista R., 1949.

Sub-race of Cónico
Elotes Cónicos

Closely related to the race Cónico and perhaps entitled to recognition as a sub-race of it are the "elote" corns of the Central Mesa (Fig. 37). These have approximately the same range of

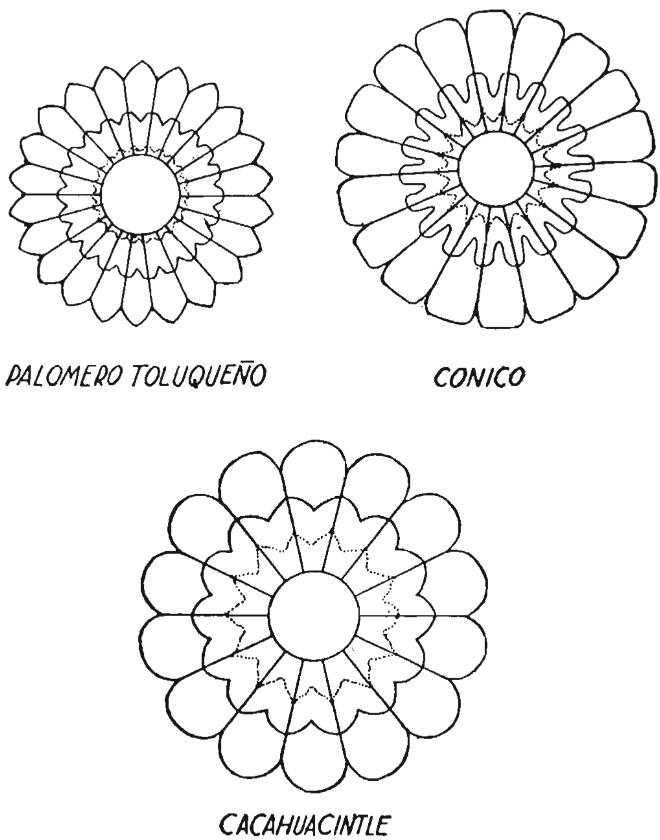


FIG. 35. A comparison of the diagrammatic ear cross sections of Palomero Toluqueño, Cónico, and Cacahuacintle.

distribution as Cónico (Fig. 38) and are usually found in every village of the Central Mesa, grown on a limited scale for consumption as roasting ears. Like the elote corns of western Mexico they have been selected for purple aleurone color, cherry pericarp color or both and probably for the same reason. These colors are

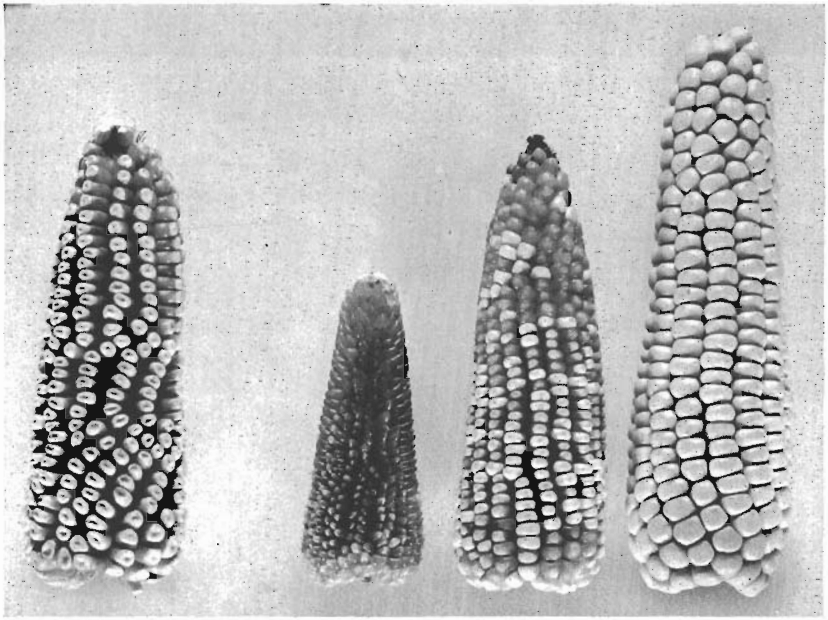


FIG. 36. Origin of Cónico. The races Cónico originated as a natural cross between Palomero Toluqueño and Cacahuacintle. From left to right, ear (1) Cónico as it is found at present, (2) Palomero Toluqueño, (3) an ear of synthetic Cónico produced by experimentally crossing Palomero Toluqueño and Cacahuacintle and (4) Cacahuacintle. Ears 1 and 3, except for segregation of kernel texture are quite similar. Scale 1 cm. = 2.46 cm.

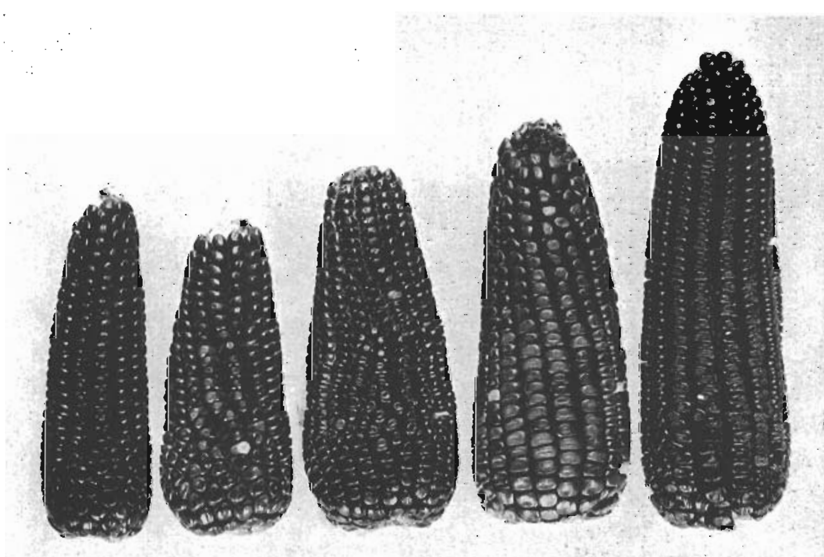


FIG. 37. Cónico Elotes. Sub-race of Cónico with similar characters except for blue aleurone, colored pericarp and floury endosperm. Scale 1 cm. = 2.90 cm.

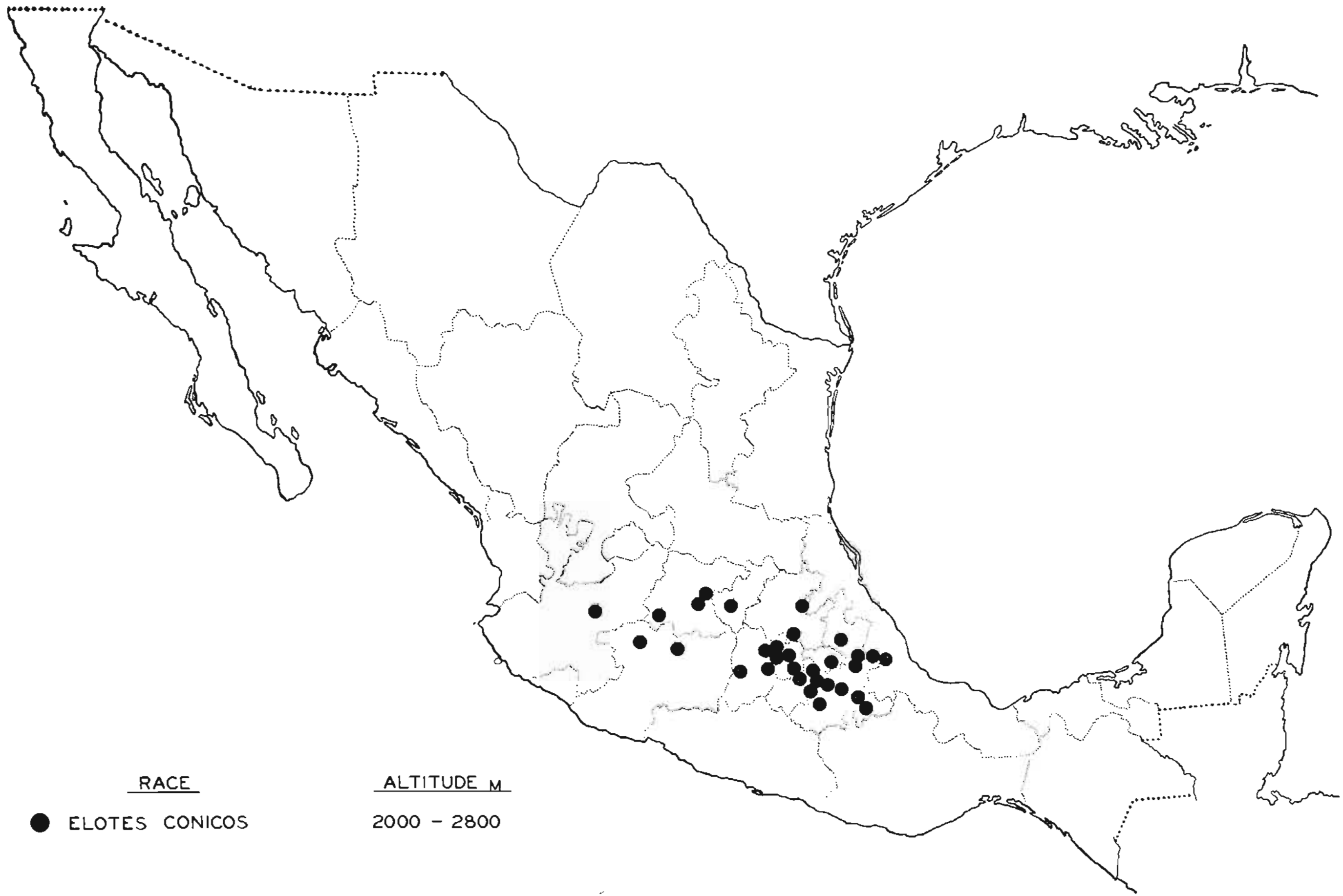


Fig. 38. Distribution of the Cónico elotes of the Mesa Central.

usually more intense in flour corn than in dent corn and selection for color has tended to keep the varieties pure for floury endosperm which is preferred in elote corns. These Cónico-like colored elote corns appear to have originated from a very strong introgression of Cónico into a highly pigmented flour corn related to Cacahuacintle. Although they show certain similarities to Cacahuacintle, they exhibit certain differences such as shorter kernel, a more slender rachis, and an absence of tesselation which indicates that the original flour corn that entered into their origin was probably

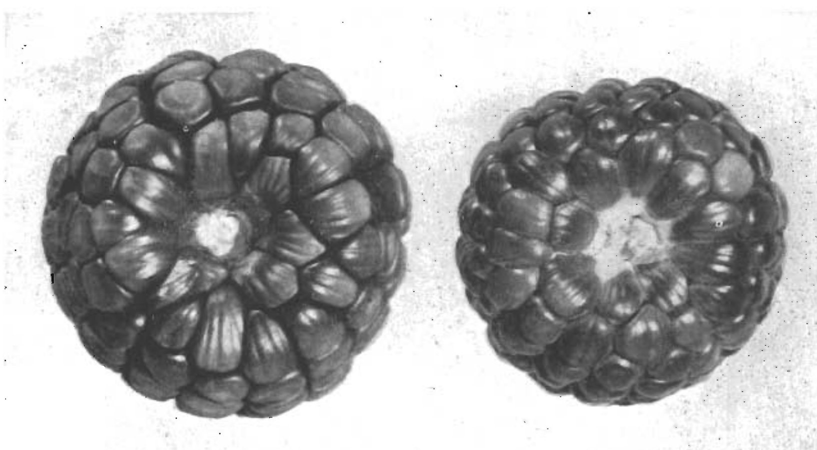


FIG. 39. Butts of Cónico Elote Ears. Note extremely small peduncle and the development of the basal kernels which are characters found in Cónico and accentuated in the elote sub-race. Scale 1 cm. = 1.05 cm.

somewhat different from Cacahuacintle. Since the elote corns differ from Cónico by two, sometimes three different genes on as many different chromosomes and by linked groups of genes associated with them, it is not surprising that the elote corns have never become completely identical to Cónico. They still exhibit some of the characters of the original flour corn including the almost completely covered butts (Fig. 39).

REVENTADOR

Plants. Short, 1.5 meters; slender stalks; medium number of tillers; low number of long narrow leaves with high venation index; general appearance of plant grass-like; sun-red color absent; pubescence very slight; moderately resistant to races of rust in central plateau of Mexico; average number of knobs 8. Adapted to lower elevations, 0–1,500 meters.

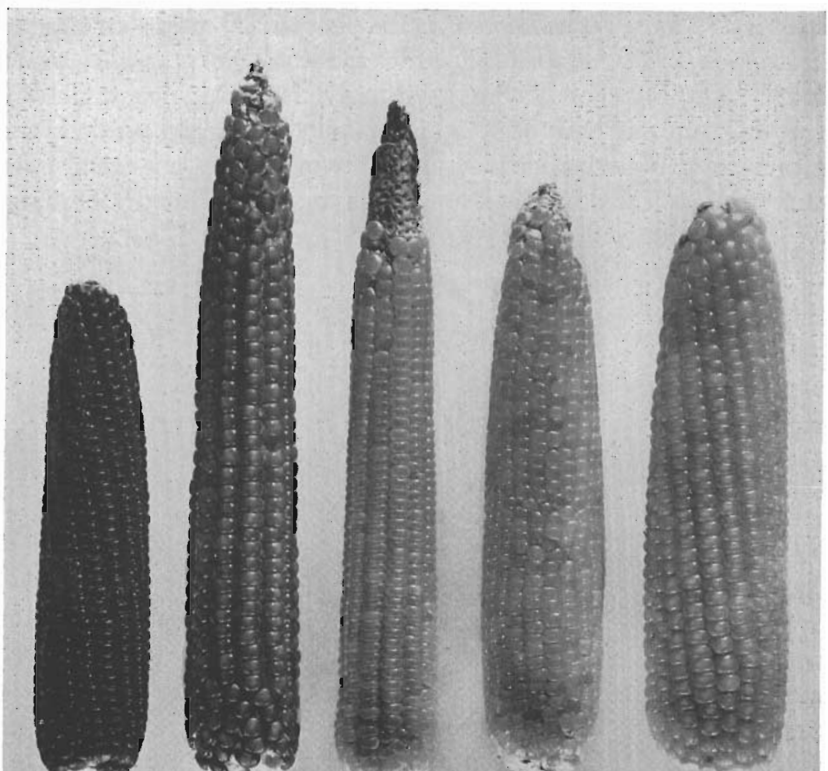


FIG. 40. Reventador, a rather variable race of pop corn in Western Mexico that is undoubtedly related to the primitive race Chapalote. It is more tripsacoid than Chapalote in its characteristics and probably originated from admixtures of Chapalote and teosinte. Red pericarp color illustrated in the two ears at left is common in this race. Scale 1 cm. = 2.11 cm.

Tassels. Long, few branches, average 8.4, secondaries few and tertiaries absent; condensation index low.

Ears, External Characters. (Fig. 40) Long, slender, cigar shape, tapering at both ends; average number of rows 11.9; small shank; mid-cob color in 50% of ears examined. Kernels small, short, rounded, smooth; striations pronounced; endosperm horny, pop type with numerous fractures, white or yellow; aleurone colorless; pericarp colorless or red.

Ears, Internal Characters. (Fig. 41) Ear diameter 26–32 mm.; cob diameter 19–21 mm.; rachis diameter 9–10 mm.; kernel length 7–9 mm.; estimated rachilla length 2.0 mm.; cob/rachis index high, 2.00; glume/kernel index medium, 0.67; rachilla/kernel index high, 0.28; pedicel hairs usually none but occasionally a few long; cupule hairs few to many long; rachis flap weak; lower glumes mostly fleshy, surface hairs few or lacking, marginal hairs numerous, intermediate, or long, margin shape broadly cordate;

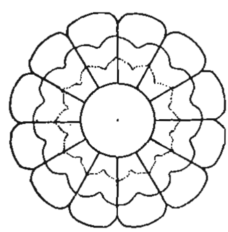


Fig. 41.

upper glumes chaffy, venation slight to intermediate, shape wrinkled to intermediate, surface hairs lacking or a few short, marginal hairs few short to many long; tunicate allele tu^w; rachis tissue horny; teosinte introgression intermediate to strong.

Distribution. Maíz Reventador is found in the same general area as Maíz Dulce and Tabloncillo (Fig. 42). Its range in elevation is from sea level to 1,500 meters, but it seems to be at its best at low elevations. Anderson (1944a) reports collections of Reventador from western Mexico, and these are shown in Fig. 42 with an A in a circle.

Additional collections made by the Oficina de Estudios Especiales, S. A. G., show that Reventador is fairly prevalent in the lowlands of Sonora, Nayarit and along the coast to the south as far as western Guerrero. Its influence on Tabloncillo in Nayarit is strongly evident. Collections other than those reported by Anderson were made from the following villages: Caoval, Colima; El Limon, Atoyac and Zapotiltec in Jalisco; Ejidos Los Penitas,

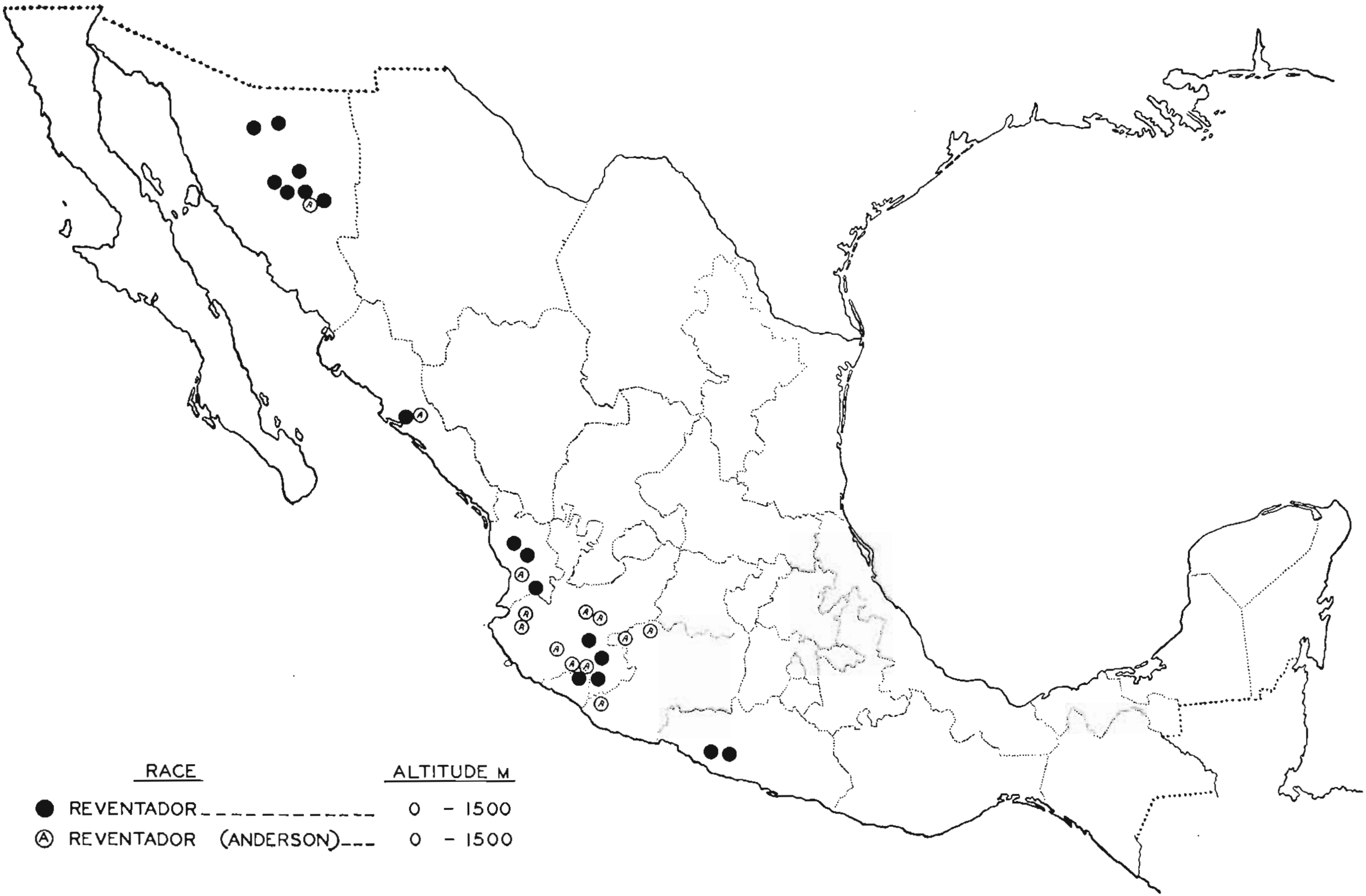


Fig. 42. Distribution of Reventador.

Chilapa, Quimichis, Milpas Viejas and Tuxpan in Nayarit; Vallecito and Puerto de Aguila and El Ocote, north of Petatlan in Guerrero; and Ures, Moctezuma, Suaqui, Sahuaripa, Santa Ana, Cocospero, and Mazatan in the state of Sonora.

Origin and Relationships. Reventador is obviously closely related to Chapalote, as has been recognized by Anderson (1944a) and as is clearly revealed by a comparison of the data in Tables 13 to 17 and internode patterns in Plate VII. Since it is more tripsacoid than Chapalote in a number of characteristics, especially venation index, knob number and induration of the rachis, we conclude that it is the product of the hybridization of Chapalote and teosinte (Fig. 43). Chapalote has not yet been found growing naturally in close proximity to teosinte, although Lumholtz has reported their interplanting. Furthermore, the archaeological remains mentioned under the discussion of the

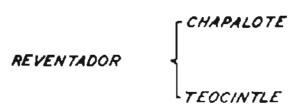


FIG. 43. The probable origin of Reventador.

origin of Chapalote would indicate that this race, or a very similar one, was once more widespread than it is now and it is reasonable to assume that at one time Chapalote and teosinte were growing in the same localities. It is evident from the distribution map for teosinte (Fig. 44) and for Chapalote (Fig. 10) that the two are found in the same general region, and with more adequate collections in northwestern Mexico it is possible that they will be found growing together at the present time. Furthermore, the distribution of Reventador, thought to have originated as a cross between Chapalote and teosinte, does overlap that of teosinte (Figs. 42 and 44). Evidence for the pre-Columbian origin of Reventador is found in the fact that it has apparently been the ancestor of several well-established races including Tabloncillo, Jala, Celaya, Cónico Norteño and Bolita.

Derivation of Name. Reventador is the common name of this race of corn in the region where it is grown. The word, Reventador, is derived from the Spanish verb "reventar", meaning to burst or

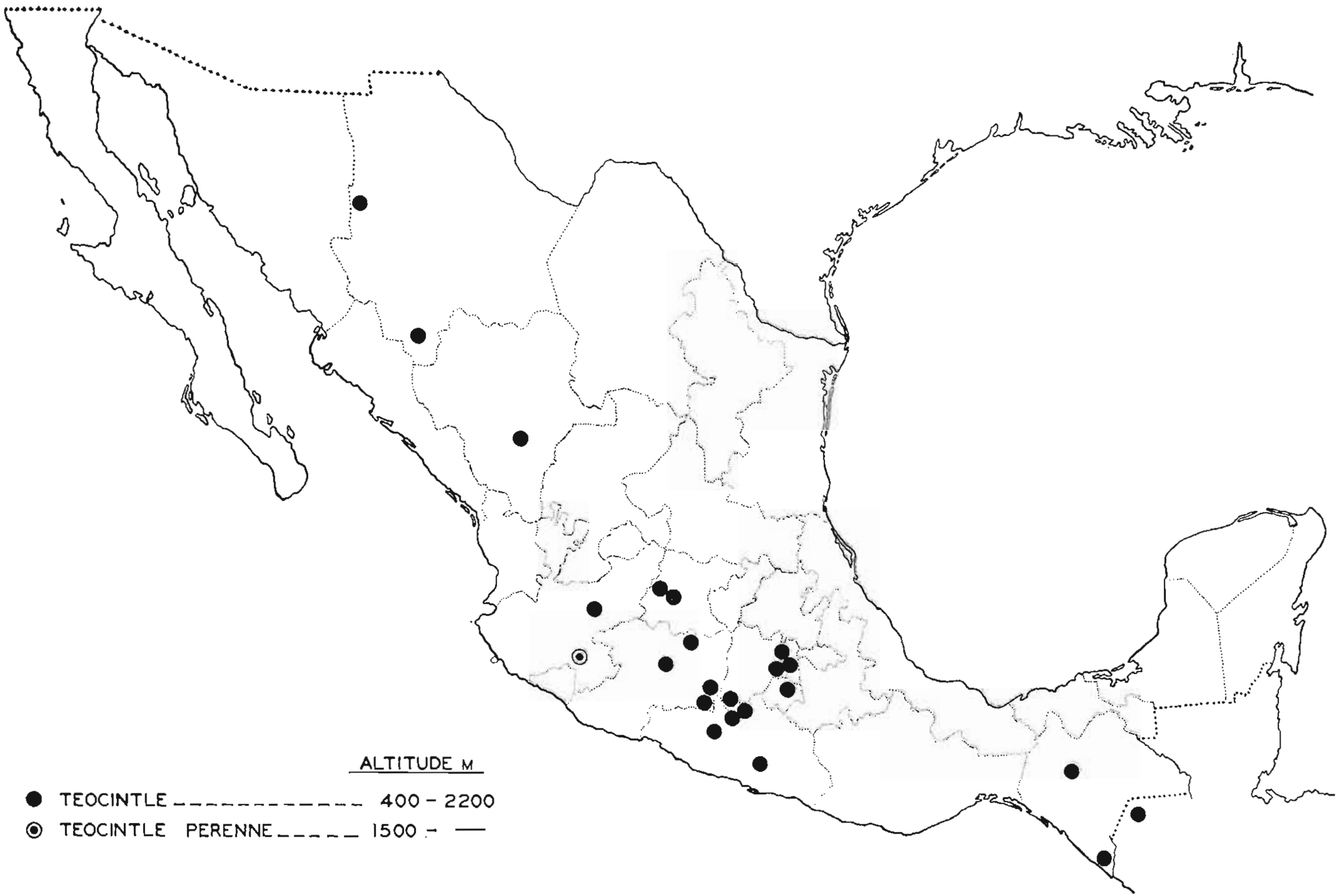


Fig. 44. Distribution of teosinte.

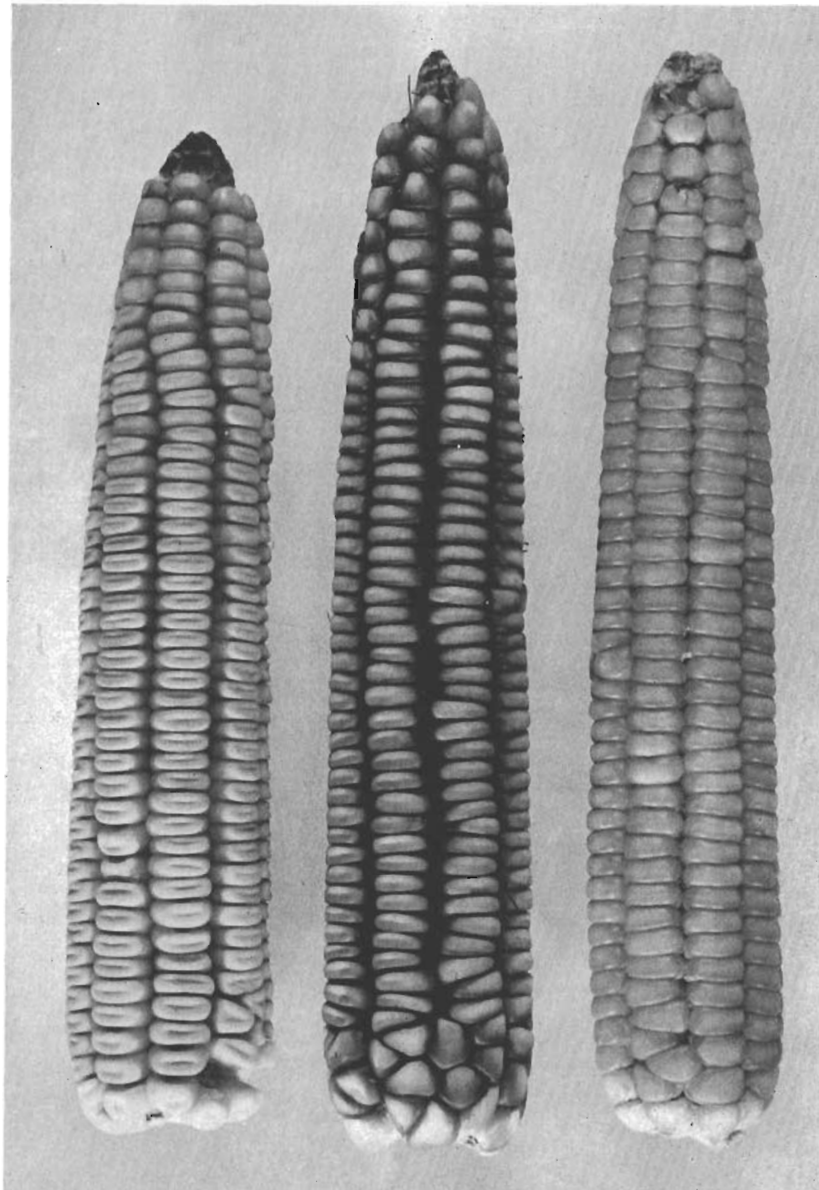


FIG. 45. Tabloncillo. Showing representative ears of the common forms of the race Tabloncillo. From left to right (1) Blanco, (2) Ahumado and (3) Perla. All three of these forms are found in the western part of Mexico primarily in the states of Nayarit and Jalisco. Perla is sufficiently distinctive in its characteristics and distribution to be regarded as a sub-race. Scale 1 cm. = 1.51 cm.

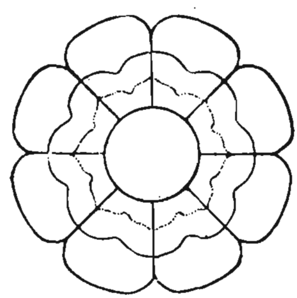
to pop, and a corn capable of popping is often referred to as "Reventador".

Special Uses. As a pop corn and for "pinole". Not known to be used for tortillas.

References. Anderson, 1944a, 1946a, 1947a.

TABLONCILLO

Plants. Medium height, 2.4 meters; early maturing; many tillers; slender stalks; intermediate number of leaves of medium width and length; general appearance grass-like; very high venation index; sun-red or purple color slight to absent; very slight pubescence; medium resistance to rust; medium number of knobs, average 7.6. Adapted to lower elevations, 0–1,500 meters.



TABLONCILLO

FIG. 46.

Tassels. Long, with few long branches widely spaced on central axis, giving open appearance to tassel; secondaries frequent, tertiaries absent; condensation index low.

Ears, External Characters. (Fig. 45) Medium length, slender, cylindrical except for slight taper at both ends; average row number 9.1 and low row number is a characteristic in which the race is strongly dominant in crosses; shank diameter medium; mid-cob color in 54% of ears examined. Kernels very wide, medium thick, and short, top surface flatly curved with pronounced denting; striations well marked; endosperm texture mostly soft starch, usually white; aleurone colorless; pericarp colorless or smoky.

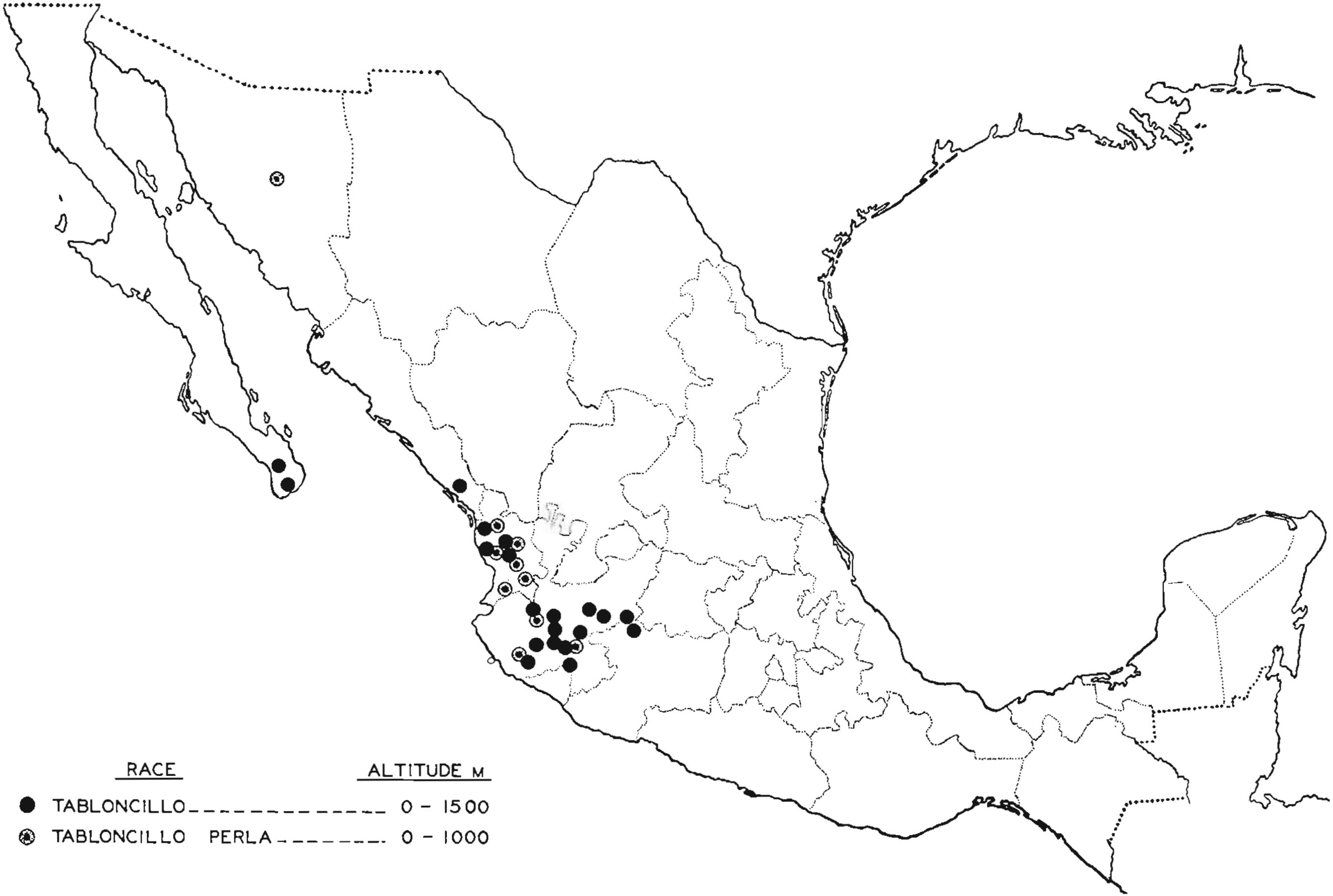


FIG. 47. Distribution of Tabloncillo and Tabloncillo Perla.

Ears, Internal Characters. (Fig. 46) Ear diameter 36–44 mm.; cob diameter 22–25 mm.; rachis diameter 11–13 mm.; kernel length 9–12 mm.; estimated rachilla length 2.1 mm.; cob/rachis index medium, 1.87; glume/kernel index medium, 0.53; rachilla/kernel index medium, 0.20; pedicel hairs many long in typical ears, few or none in the form "Perla"; cupule hairs intermediate in number, long; rachis flap intermediate to strong; lower glumes mostly horny, few scattered hairs, the margin undulate; upper glumes mostly fleshy, stiff, usually glabrous except for short marginal hairs, venation slight or lacking; tunicate allele predominately tu^{w}; rachis tissue horny; teosinte introgression marked.

Distribution. The center of distribution of Tabloncillo is in western Mexico in the Jaliscan plains and coastal plain of Nayarit (Fig. 47). It has been collected along the west coast as far north as Ures, Sonora, and in Baja California.

Three more or less distinct types of this race are recognized, as shown in the photograph Fig. 45; namely, Tabloncillo Blanco, Tabloncillo Ahumado, and Tabloncillo Perla. Tabloncillo Blanco is the most common form and is the one described above. The "Ahumado" type is essentially identical with the "Blanco" type except for a smoky pericarp color which may be related to the brown pericarp of Chapalote, one of the putative ancestors of the race, or it may be a dilute form of the pericarp color found in teosinte. At the present time there is rather strong selection against the smoky color in some areas. The "Perla" type differs from the other two in a number of characteristics, but principally in the hard flinty texture of the grain.

In the distribution map (Fig. 47) no distinction is made between the types "Blanco" and "Ahumado". Both are generally distributed throughout the area from 0–1,500 meters elevation but are most prevalent in Jalisco at 1,000 to 1,500 meters elevation. On the other hand, Tabloncillo Perla, although found in the vicinity of Ameca, Autlan and Sayula in Jalisco up to 1,200 meters elevation, is definitely more prevalent at lower elevations principally in the state of Nayarit. Outside the areas already mentioned it has been found at low elevations in the vicinity of Ures, Sonora.

Origin and Relationships. Tabloncillo is almost certainly the result of introgression of teosinte into an eight-rowed flour corn very similar to Harinoso de Ocho.[5] We suspect, however, that most of the teosinte genes came not from teosinte directly but through Reventador as shown in Fig. 48. This relationship can be observed from the ears illustrated in Fig. 49 and is strongly indicated by all available data. In Table 2 it is evident that Tabloncillo is either intermediate or resembles one or the other of the putative parents in the measurements or scores for many of the 35 characters and indices listed. It is only slightly less tripsacoid than Reventador in several characteristics including

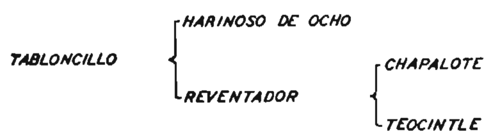


FIG. 48. The probable origin of Tabloncillo.

knob numbers. Furthermore, there is a high degree of introgression of Reventador into Tabloncillo (Fig. 50) still going on today and the most Reventador-like, Tabloncillo "Perla" (Figs. 45 and 50), is more tripsacoid than the more common types "Blanco" and "Ahumado". All this suggests, although it does not finally prove, that Tabloncillo is a derivative of Reventador. That it is also a derivative of Harinoso de Ocho or something similar to it is even more strongly suggested from a study of the data in Table 2. The common type of Tabloncillo resembles Harinoso de Ocho more closely in more characters than it does Reventador and is exactly the kind of corn to be expected from the introgression of Reventador into a flour corn like Harinoso de Ocho. It resembles Harinoso de Ocho very closely (Fig. 51) in ear diameter and row number; in width, thickness and length of kernel; in diameter of the cob and rachis; and in the glume/kernel and rachilla/kernel

[5] Since this was written we have obtained from Mr. G. Edward Nicholson ears of a race of Peruvian maize known locally as "Maíz pardo" which are almost identical in their general aspects to ears of Tabloncillo except that the kernels are floury. Cytological studies of this newly-discovered race have not yet been made but studies of the anthocyanin pigment pattern of the seedlings indicate that the race is an indigenous Peruvian one and not a recently introduced one. The hypothesis that Tabloncillo has originated from a South American flour corn (probably modified by teosinte introgression) is now supported by direct evidence.

FIG. 49. Origin of Tabloncillo. The evidence points to Tabloncillo having been derived from a natural cross between Reventador and Harinoso de Ocho. Left to right (1) Harinoso de Ocho, (2) Tabloncillo and (3) Reventador. These three races are still grown in the same general area of Western Mexico.
Scale 1 cm. = 1.67 cm.

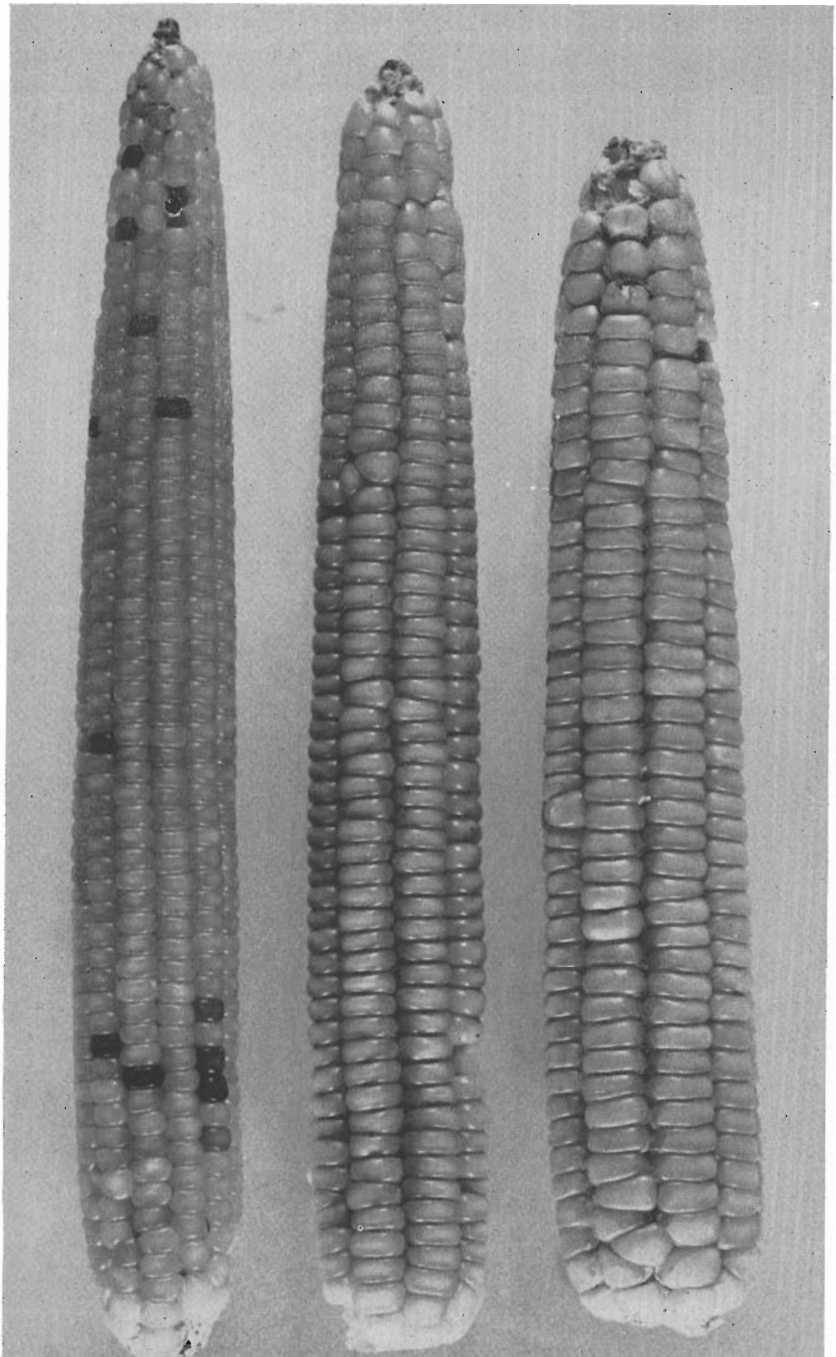


FIG. 50. Introgression of Reventador into Tabloncillo Perla. Left to right (1) Reventador, (2) intermediate between Reventador and Tabloncillo and (3) Tabloncillo Perla. The flinty kernel type of Tabloncillo Perla is selected for lower altitudes in Nayarit because of greater resistance to weevil damage. Scale 1 cm. = 1.39 cm.

indices. Furthermore, pedicel hairs are common in all three forms of Tabloncillo and these probably come from the original eight-rowed flour corn, one of the putative parents of Tabloncillo. Harinoso de Ocho and its sub-race, Elotes Occidentales, both have

TABLE 2. Comparison of Tabloncillo With Its Probable Progenitors, Harinoso de Ocho and Reventador.

	Harinoso de Ocho	*Tabloncillo*	*Reventador*
Plant Characters			
Height (meters)	1.6	2.4	1.5
No. of Leaves	12.1	14.6	11.0
Width of Leaves (cm.)	8.6	8.6	7.1
Length of Leaves (cm.)	84.3	79.8	75.7
Venation Index	2.56	3.56	3.33
Tassel Characters			
Length (cm.)	41.9	40.0	40.7
Length of Branching Space (cm.)	11.2	9.0	7.6
Percent of Branching Space	25.0	23.0	19.0
No. of Branches	10.0	8.8	8.4
Percent Secondary Branches	12.0	11.5	5.9
Condensation Index	1.05	1.10	1.15
External Characters of Ear			
Length (cm.)	19.1	16.4	16.5
Diameter (cm.)	3.8	4.1	3.2
Row Number	8.0	9.1	11.9
Shank Diameter (mm.)	14.0	11.0	8.8
Width of Kernel (mm.)	12.0	11.5	7.4
Thickness of Kernel (mm.)	4.4	4.3	3.6
Length of Kernel (mm.)	11.2	10.3	7.3
Internal Characters of Ear			
Diameter of Cob (mm.)	21.7	23.4	19.6
Diameter of Rachis (mm.)	10.7	12.5	9.8
Length of Rachilla (mm.)	2.6	2.1	2.0
Cob/rachis Index	2.03	1.87	2.00
Glume/kernel Index	0.49	0.53	0.67
Rachilla/kernel Index	0.23	0.20	0.28
Pedicel Hairs	3	0–4	0–3
Rachis Flap	2–3	2–3	1
Rachis Induration	1	2	1
Teosinte Introgression	2	2–3	2–3
Physiological, Genetic and Cytological Characters			
No. Days to Anthesis	—*	107	106
Rust Resistance	1	1–2	1–2
Pilosity	0	1	1
Sheath Color	0	0–1	0
Mid-cob Color, Percent	0	54	50
Chromosome Knobs, Range	—	5–9	5–10
Average No.	—	7.6	8

* In this table and all that follow a dash indicates that data are not available.

prominent pedicel hairs. Tabloncillo is also very similar to Harinoso de Ocho or intermediate between its two putative parents in internode pattern, as shown in Plate VII.

Further evidence that Tabloncillo is the result of the introgression of Reventador into Harinoso de Ocho comes from inbreeding. Upon inbreeding, Tabloncillo frequently segregates ears of eight-rowed flour corn. Even the Reventador-like type, "Perla", occasionally gives rise to ears of eight-rowed flour corn.

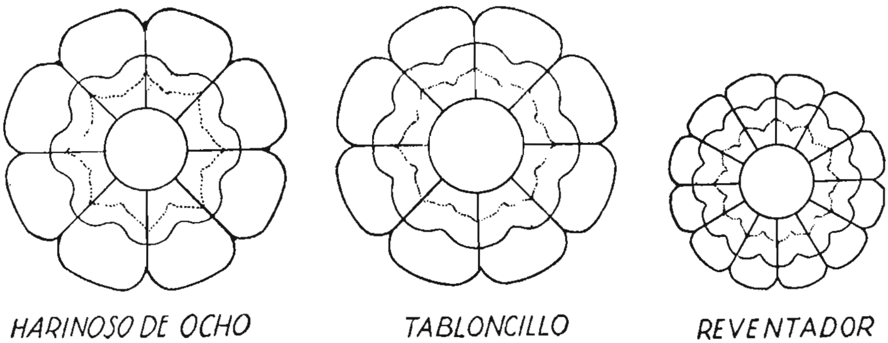


Fig. 51. A comparison of the diagrammatic ear cross sections of Harinoso de Ocho, Tabloncillo and Reventador.

It is probable that Tabloncillo in the early stages of its formation resulted from the introgression of both Chapalote and Reventador and possibly some teosinte directly into Harinoso de Ocho. There is little reason to doubt that Tabloncillo "Ahumado" has received its brown mid-cob color and weak brown pericarp color, which gives it the smoky appearance, through the influence of Chapalote. The shape of the lower glume in "Ahumado", especially in its flat upper margin, is much more like that in Chapalote than in Reventador while the reverse is true in Tabloncillo "Blanco" and "Perla". The introgression still going on today, however, into what is now Tabloncillo is primarily from Reventador. Both Harinoso de Ocho and Chapalote are now only rarely found in the range at present occupied by Tabloncillo, but their immediate counterparts, the elote corns of western Mexico and Reventador, although limited in the amount grown either overlap or are almost identical with the predominating type of Tabloncillo in their range of distribution (Figs. 24, 42 and 47).

Indirect evidence for the pre-Columbian origin of Tabloncillo lies in the fact that it has been the parent of several other races including Jala, Celaya, Cónico Norteño and Bolita. Brown and Anderson (1948) consider the Hickory King variety of the United States to be related to Tabloncillo. Since Hickory King frequently has flexible cobs it is more probably related to the flexible-cobbed Olotillo of Chiapas.

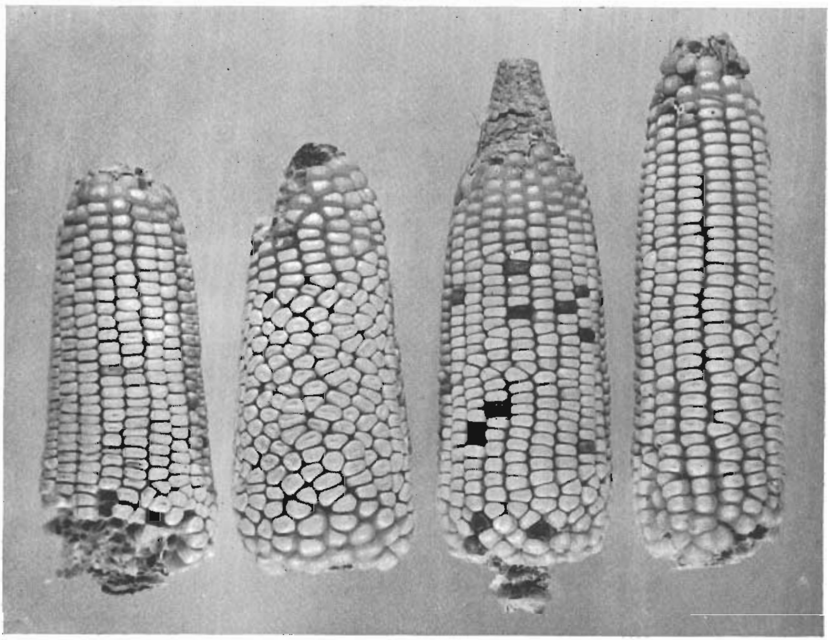


FIG. 52. Tehua. This race has the largest rachis, cob, and ear diameters of any of the races that have been found in Mexico. The plants are very tall, leafy and late. Scale 1 cm. = 2.74 cm.

Derivation of Name. Common name used in area in which the race is grown referring to the wide, short, thick kernels on the ear. "Tablon" in Spanish means plank or thick board and "tabloncillo" little plank, which is fairly descriptive of the kernels.

References. Brown and Anderson, 1948; Chávez, 1913; Anderson, 1946a (as Narrow Ear); Wellhausen, 1947.

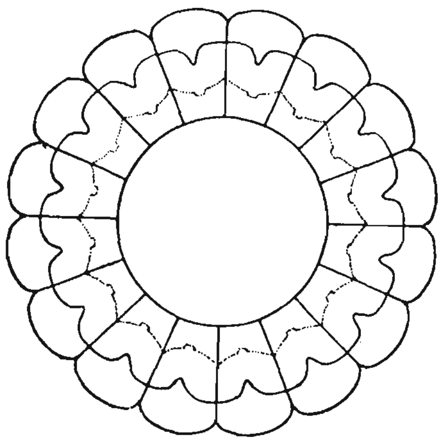
TEHUA

Plants. Very tall, sometimes reaching 6 meters in its native habitat; extremely late maturing; leaves numerous, 20.5 per plant;

medium venation index; leaf sheaths slightly pubescent and almost lacking sun-red color; medium resistance to rust. Adapted to medium elevations 600–1,000 meters.

Tassels. Long, well branched; branches 27.7 per tassel, arising from almost half the length of the main axis; high number of secondaries; tertiaries rare; condensation index medium.

Ears, External Characters. (Fig. 52) Long, very broad, slightly conical with a gradual uniform taper from base to tip; high average row number 17.0; shank diameter very large, 21.5 mm.;



TEHUA

FIG. 53.

mid-cob color present in 45% of ears. Kernels medium size, medium dented; striations very slight; endosperm white, medium hard.

Ears, Internal Characters. (Fig. 53) Ear diameter 55–58 mm.; cob diameter 41–43 mm.; rachis diameter 26–29 mm.; length kernels 11–12 mm.; estimated rachilla length 2.9 mm.; cob/rachis index low, 1.53; glume/kernel index medium, 0.63; rachilla/kernel index medium, 0.25; pedicel hairs few to many, long; cupule hairs few to many, intermediate to long; rachis flap weak to intermediate; lower glumes horny, few scattered hairs, few marginal hairs, the margins deeply cordate; upper glumes fleshy, intermediate to stiff; few long surface hairs, few long marginal hairs; tunicate allele tu^{w}; rachis tissue horny to bony; teosinte introgression intermediate.

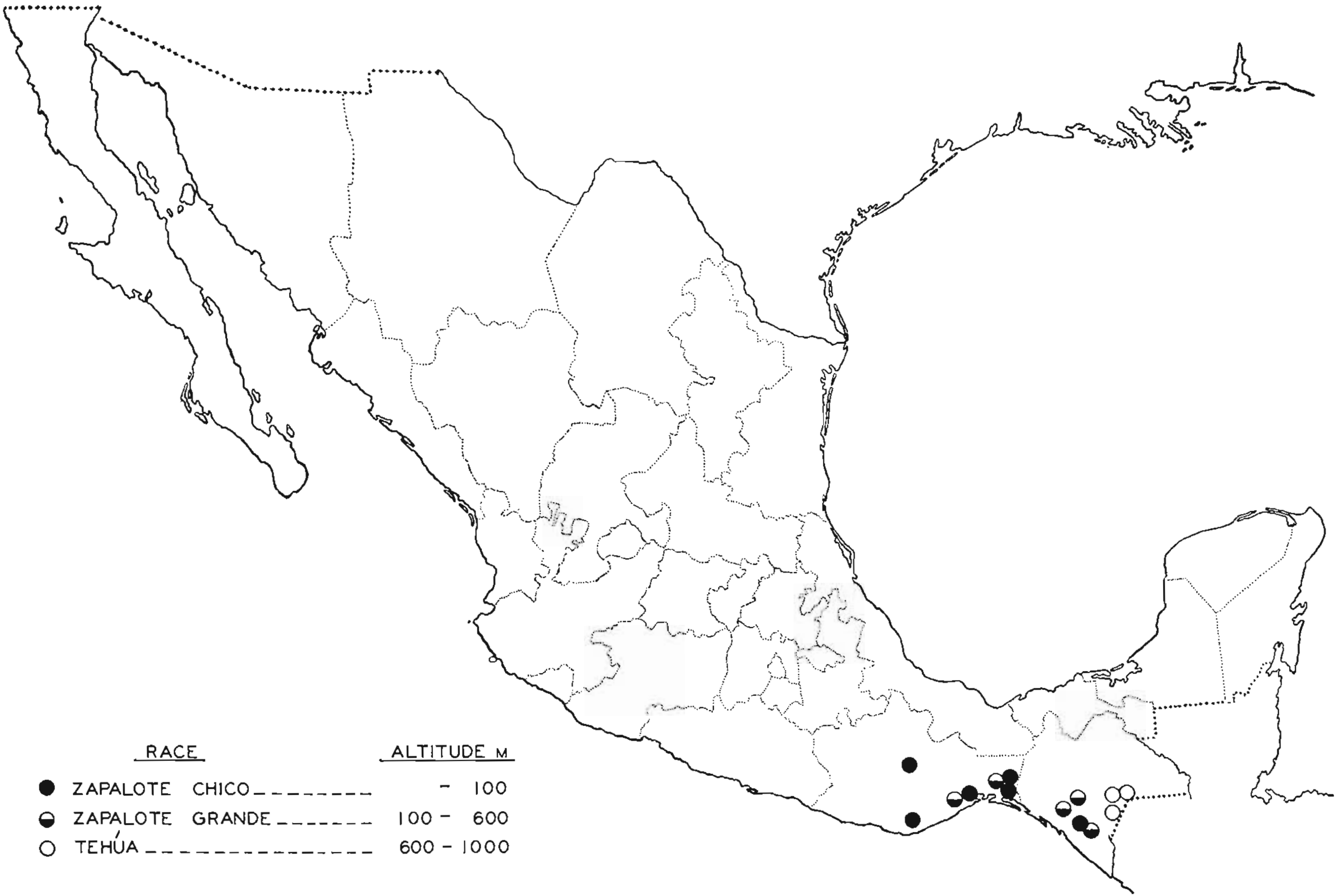


Fig. 54. Distribution of Zapalote Chico, Zapalote Grande and Tehua.

Distribution. Tehua has been found only in the state of Chiapas, in the vicinity of Zapotal, Potrerillo, Comalapa, Avispero and Finca Prusia at elevations of 600 to 1,000 meters close to the Guatemalan border. Its distribution is shown by the clear circles in Fig. 54.

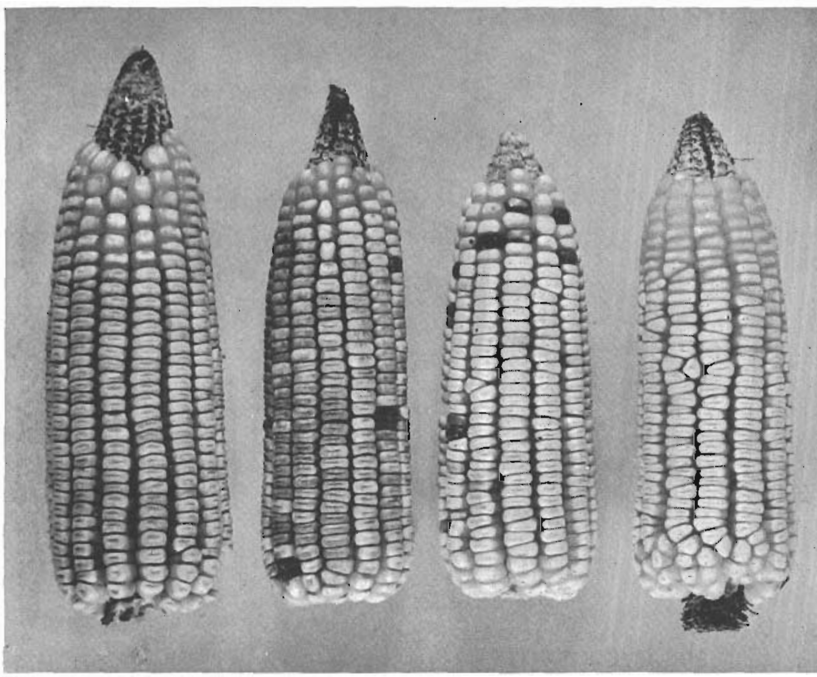


FIG. 55. Tepecintle. This race is more common in Guatemala than in Mexico. It has a high number of chromosome knobs and in some respects is the most tripsacoid race known. Large cobs that fail to set seed at the tip are characteristics of the ears. Scale 1 cm. = 2.46 cm.

Origin and Relationships. The origin of Tehua is still obscure. It has the largest diameter of rachis, cob and ear of any of the 25 races and this fact suggests that Tehua has affinities with Tepecintle, Zapalote Grande and Comiteco, to be described later. It is quite tall, leafy and late in maturity and in these characteristics closely resembles Comiteco. We suspect that Tehua, like Tepecintle, is a product of the introgression of teosinte into a race of flour corn possessing large cobs and many rows. If so, it represents one of the less tripsacoid races that may have been formed by such introgression for it is by no means strictly intermediate between its parents. Thick-cobbed, high-rowed flour corns are occasionally found in Chiapas but are even more common in Guatemala. Some of the types found in Guatemala are illustrated by Mangelsdorf and Cameron (1942) in their Plate XXV. A more exact conclusion with respect to the origin of Tehua must await the further study of these types. Since the origin of Tehua needs further study, it seems best not to include a genealogy, necessarily highly speculative, of this race.

Derivation of Name. Common name used for this kind of corn in the regions where it was found. Its derivation is unknown.

TEPECINTLE

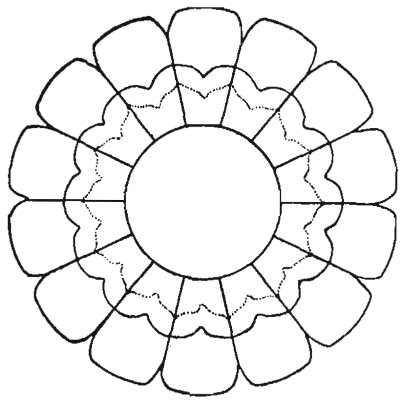
Plants. Medium height; medium maturity; few tillers, number of leaves medium; venation index medium; slight color; slight pubescence; highly susceptible to rust; number of knobs medium high, average 9.0. Adapted to lower elevations, 0–600 meters.

Tassels. Long, profusely branched, secondaries very numerous, tertiaries frequent; condensation low.

Ears, External Characters. (Fig. 55) Short, broad, cylindrical with slight taper near tip; tip end of cob, usually 2–3 cms., seldom sets seed. Mid-cob color present in 42% of ears; average number of rows 11.8; shank diameter medium; kernels medium in size, strong denting; striations slight; endosperm medium hard, white; aleurone and pericarp colorless.

Ears, Internal Characters. (Fig. 56) Ear diameter 45–60 mm.; cob diameter 27–39 mm.; rachis diameter 16–24 mm.; kernel length 10–13 mm.; estimated rachilla length 3.3 mm.; cob/rachis index low, 1.60; glume/kernel index medium, 0.52; rachilla/kernel index high, 0.28; pedicel hairs none or rare; cupule hairs variable, few short to intermediate long; rachis flap variable, weak to strong; lower glumes horny, glabrous or sparsely hairy, marginal hairs few to many, intermediate to long, margin shape broadly cordate; upper glumes fleshy, stiff, few short hairs mostly basal, marginal hairs few or none; tunicate allele tu^w; rachis tissue horny to bony; teosinte introgression very strong.

Distribution. Tepecintle, as shown in Fig. 57, has been found principally in the coastal areas of Chiapas and Oaxaca. In Oaxaca it was collected near Pochutla and Pluma Hidalgo at 100 to 600 meters elevation. In Chiapas it was collected around San Felipe Escuintla at 100 meters elevation.



TEPECINTLE

FIG. 56.

Origin and Relationships. Tepecintle, at least as it occurs in Guatemala (Mangelsdorf and Cameron, 1942, Plate XXVI) has the highest chromosome knob number of any race of maize known and it is in many respects the most tripsacoid of races. Furthermore, it occurs in a region in Guatemala where one of the most highly tripsacoid varieties of teosinte is found. Nevertheless, it has a very large cob and a relatively high row number, characters which it must have received from its maize rather than from its teosinte parent. Tepecintle, therefore, appears to us to be the product of the hybridization, probably in Guatemala, of teosinte with a race of flour corn possessing large cobs and many rows. The probable relationship is diagrammed in Fig. 58.

This origin postulated for Tepecintle is the same as suggested for Tehua. Evidence indicates that the differences between them are due to the degree of teosinte introgression into a common putative parent; namely, a large-cobbed, many-rowed flour corn. Tepecintle undoubtedly has been the recipient of much more teosinte germplasm than has Tehua. It has a smaller cob and

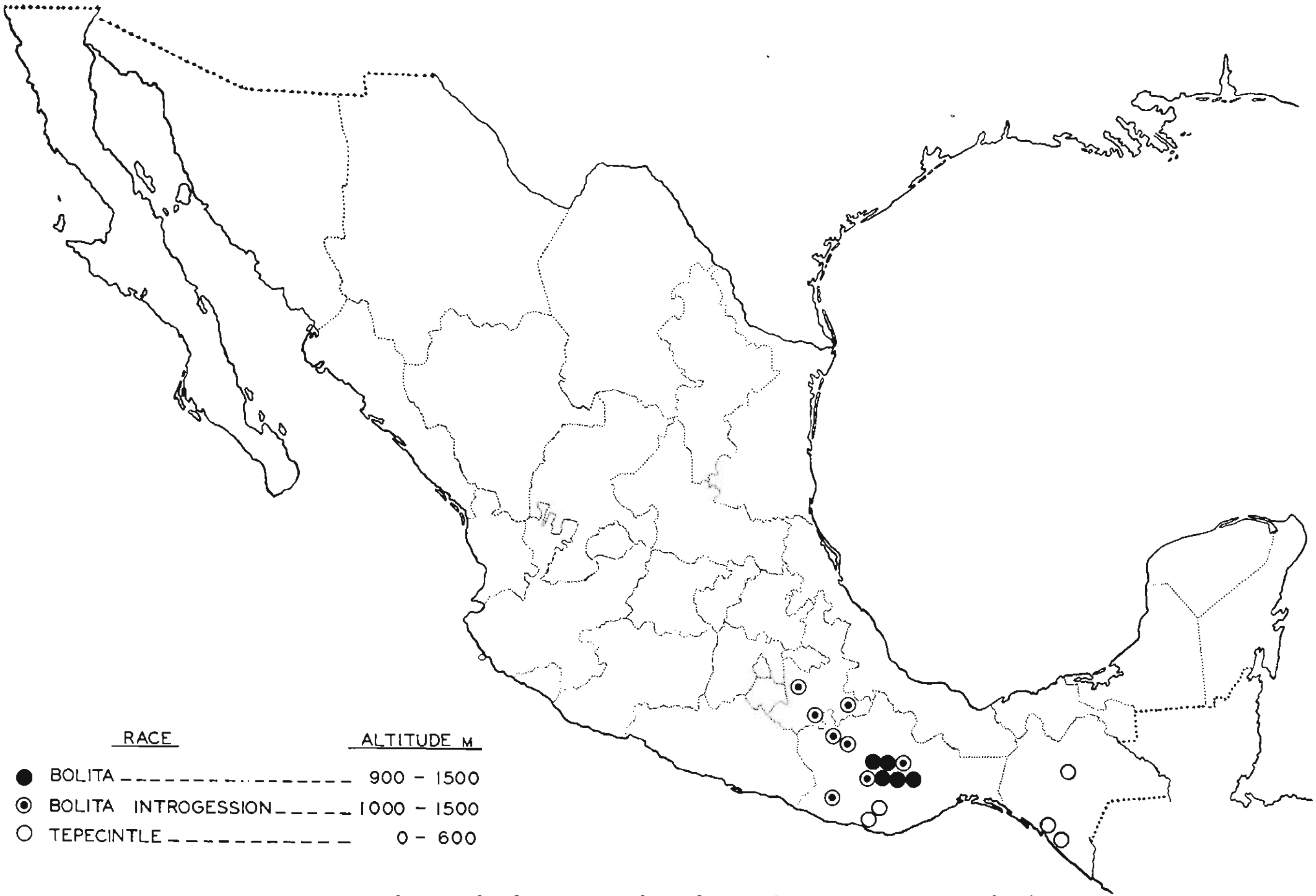


FIG. 57. Distribution of Bolita, Tepecintle, and types showing introgression of Bolita.

rachis diameter, and a smaller glume/kernel index than Tehua, and also lacks pedicel hairs whereas Tehua has many long pedicel hairs. It differs further in producing much shorter, earlier maturing plants having ears with a reduced row number and a smaller shank diameter. The two are quite similar, however, in general characteristics of ear as evident from the illustrations in Figs. 52 and 55 and from the diagrammatic cross sections in Plate V. These ear similarities together with the likeness in tassels indicate that both stem from some large-cobbed, many-rowed flour-corn parent.

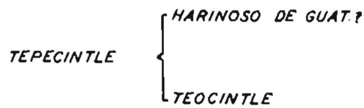


FIG. 58. The probable origin of Tepecintle.

Since Tepecintle has entered into the ancestry of a large number of other races including Zapalote Chico, Zapalote Grande, Tuxpeño, Vandeño, Chalqueño, Celaya, Cónico Norteño and Bolita, it is undoubtedly of ancient origin. Tepecintle or derivatives of it are also now widely distributed in the countries of Central America, South America and the Caribbean. From the standpoint of its influence upon modern races and varieties of maize, Tepecintle is one of the most important of known races.

Derivation of Name. Common name used in southern Oaxaca, derived from the Nahuatl, "tepetl" meaning hill, and "cintle" meaning maize, or in other words hill-maize.

References. Mangelsdorf and Cameron, 1942 (as Tripsacoid type).

COMITECO

Plants. Very tall, often 4 to 5 meters in its native habitat; late maturing; few tillers; thick stalks; leaves numerous, 20 per plant, broad; leaf sheaths slightly pubescent and with medium sun-red color; medium resistance to rust; knob number medium, 5.6. Adapted to medium elevations, 1,100–1,500 meters.

Tassels. Long, profusely branched; average number of branches 21.3, arising from a third of the length of the main axis; secondaries numerous; tertiaries absent; condensation index low.

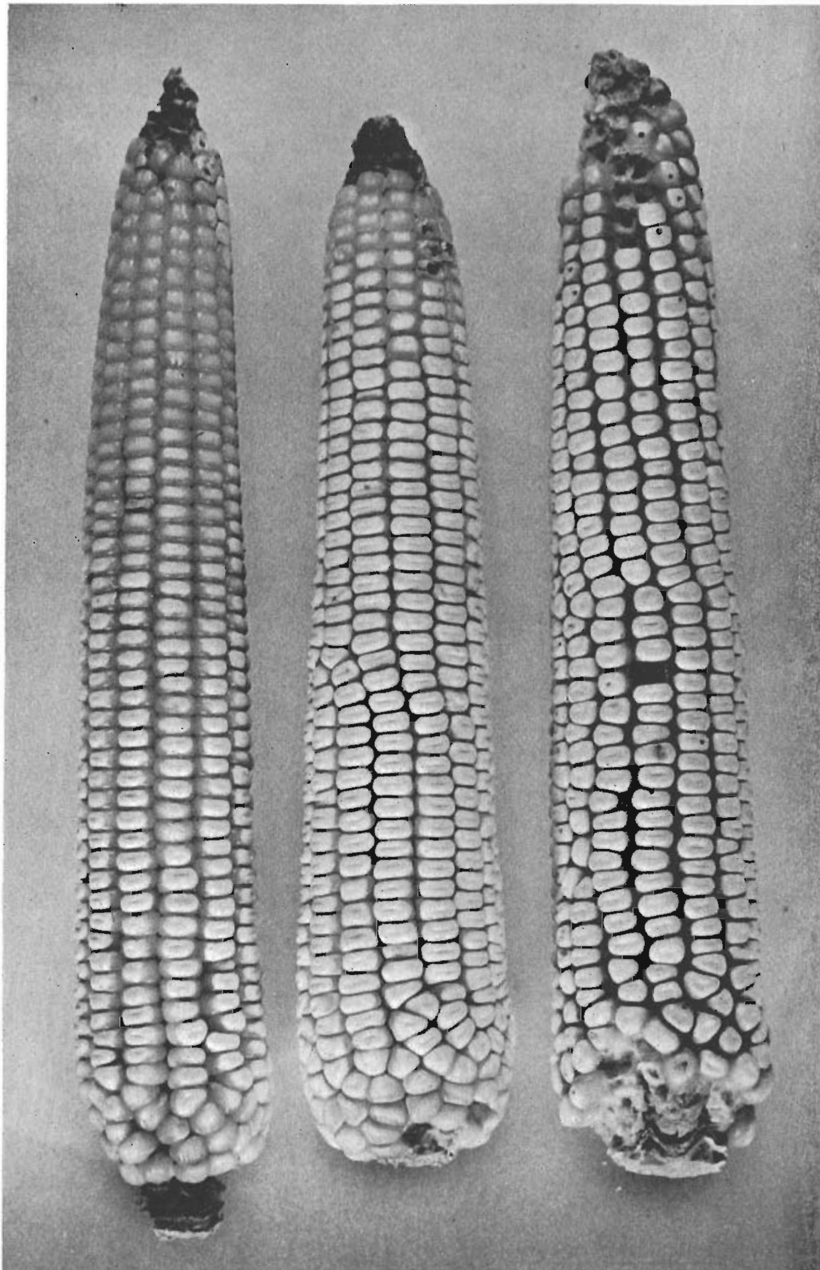
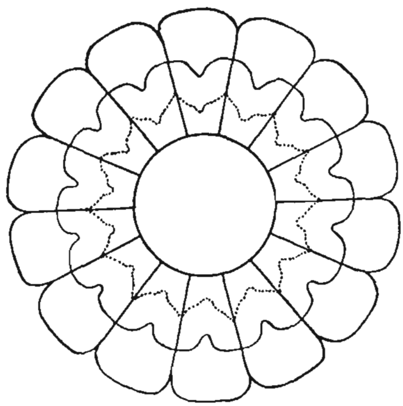


FIG. 59. Comiteco. This race has a very limited distribution in Southern Mexico near Guatemala. It is characterized by late, vigorous plants that produce very large ears. Scale 1 cm. = 2.03 cm.

Ears, External Characters. (Fig. 59) Long, broad, slightly conical ears with a medium number of rows, average 13.5; mid-cob color infrequent, only in 4% of ears examined; cob thick and rigid; shank diameter very large. Kernels medium wide, thick, medium long, rounded and smooth; striations slight to absent; endosperm medium hard, white or yellow; aleurone and pericarp colorless.



COMITECO

Fig. 60.

Ears, Internal Characters. (Fig. 60) Ear diameter 50–55 mm.; cob diameter 32–37 mm.; rachis diameter 16–21 mm.; kernel length 13–14 mm.; estimated rachilla length 3.3 mm.; cob/rachis index medium, 1.86; glume/kernel index medium, 0.58; rachilla/kernel length medium, 0.24; pedicel hairs few to intermediate, long; cupule hairs the same; rachis flap strong; lower glumes horny, many long hairs on the margins and shoulders, the margins broadly cordate; upper glumes chaffy to fleshy, stiff, venation slight or absent, many long hairs on the margins and base of the glumes; tunicate allele tu^{w} or higher; rachis tissue intermediate; teosinte introgression intermediate.

Distribution. Comiteco is most commonly found in a relatively small area near Comitan and Juncana in Chiapas at elevations from 1,100 to 1,500 meters as shown by the black circles in Fig. 61. Other nearby places in Chiapas from which it has been collected are: Morelia, Margaritas, Altamirano, Yaltzi, El Retiro and Col.

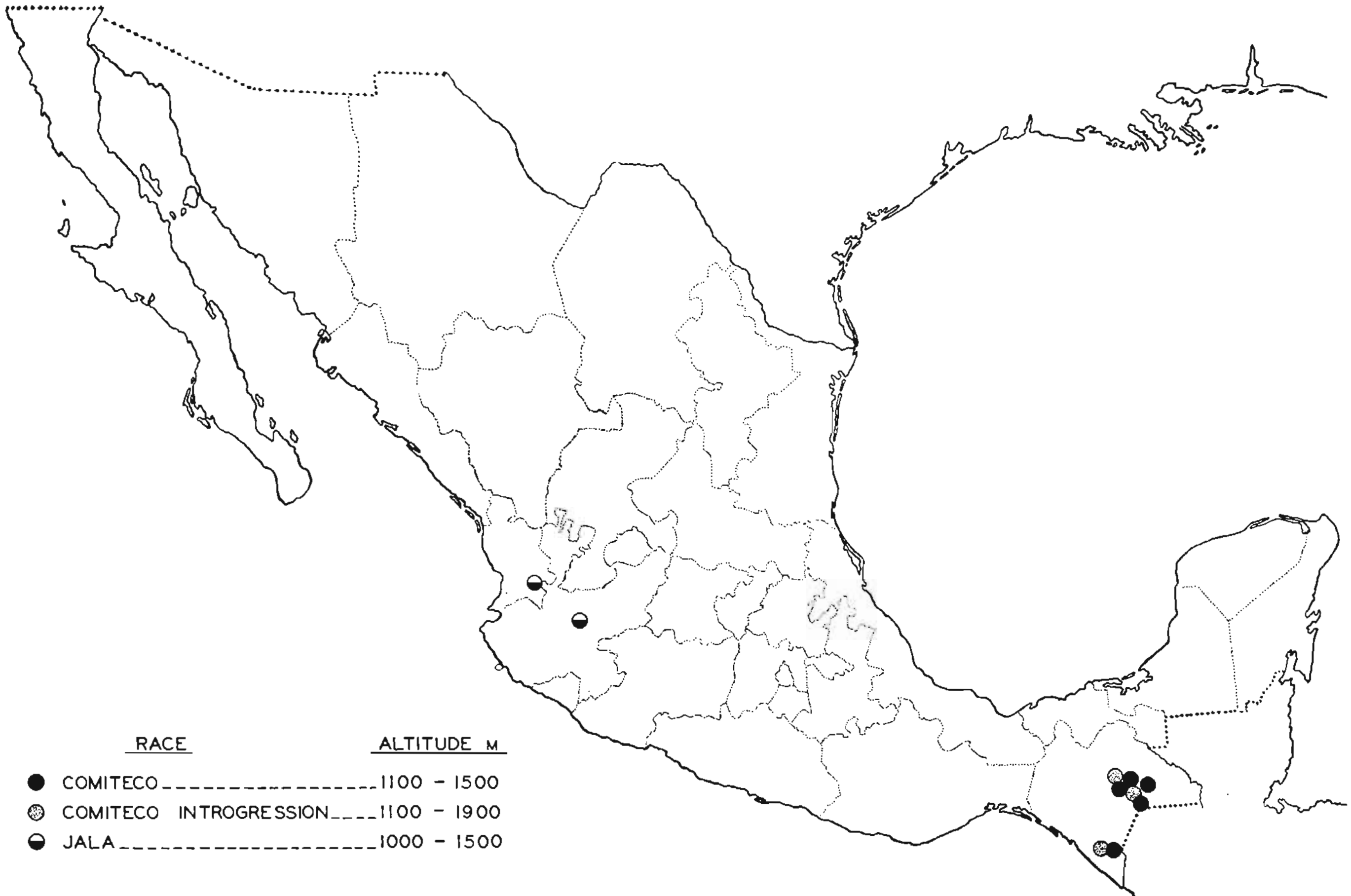


FIG. 61. Distribution of Comiteco, Jala and types showing introgression of Comiteco.

Hidalgo. Varieties showing strong introgression of Comiteco (stipled circles, Fig. 61) were collected from Motozintla, Zapaluta, Teopisca, Huixtla, San Jeronimo and La Grandeza in southern Chipias, close to the area where both Salpor and Olotón exist. Varieties more or less intermediate between Comiteco and Olotón were collected up to 1,900 meters elevation.

Origin and Relationships. Comiteco has the characters to be expected of a hybrid of Olotón and Tehua or some closely related derivative of the thick-cobbed, high-rowed Guatemalan flour corn which sometime during its history accumulated an appreciable amount of teosinte germplasm. Its probable genealogy is shown

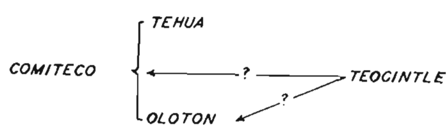


FIG. 62. The probable origin of Comiteco.

in Fig. 62, and as indicated in the diagram it may have acquired some of its teosinte germplasm through Olotón or from teosinte directly. Comiteco resembles one or the other of its immediate putative parents or is intermediate between them in many of its characters as shown by the ears (Fig. 63) and in Table 3. It is quite similar to Tehua in its late maturity, tall plants, number of leaves, rust resistance, pilosity, ear and shank diameter and internode pattern (Plate VII). On the other hand, in width of leaves, venation index, length of branching space in the tassel, condensation index and sheath color, it resembles Olotón. In many of the other characters it is intermediate. The intermediate condition of Comiteco between Olotón and Tehua in both external and internal characters of the ear is clearly illustrated in Fig. 64. Since Comiteco has participated in the formation of at least one distinct race described later as Jala, it is regarded as pre-Columbian in origin.

Derivation of Name. From the name of the city of Comitán in Chiapas, approximately the center of the geographical range of this race.

References. Cuevas Ríos, 1947 (Juncana).

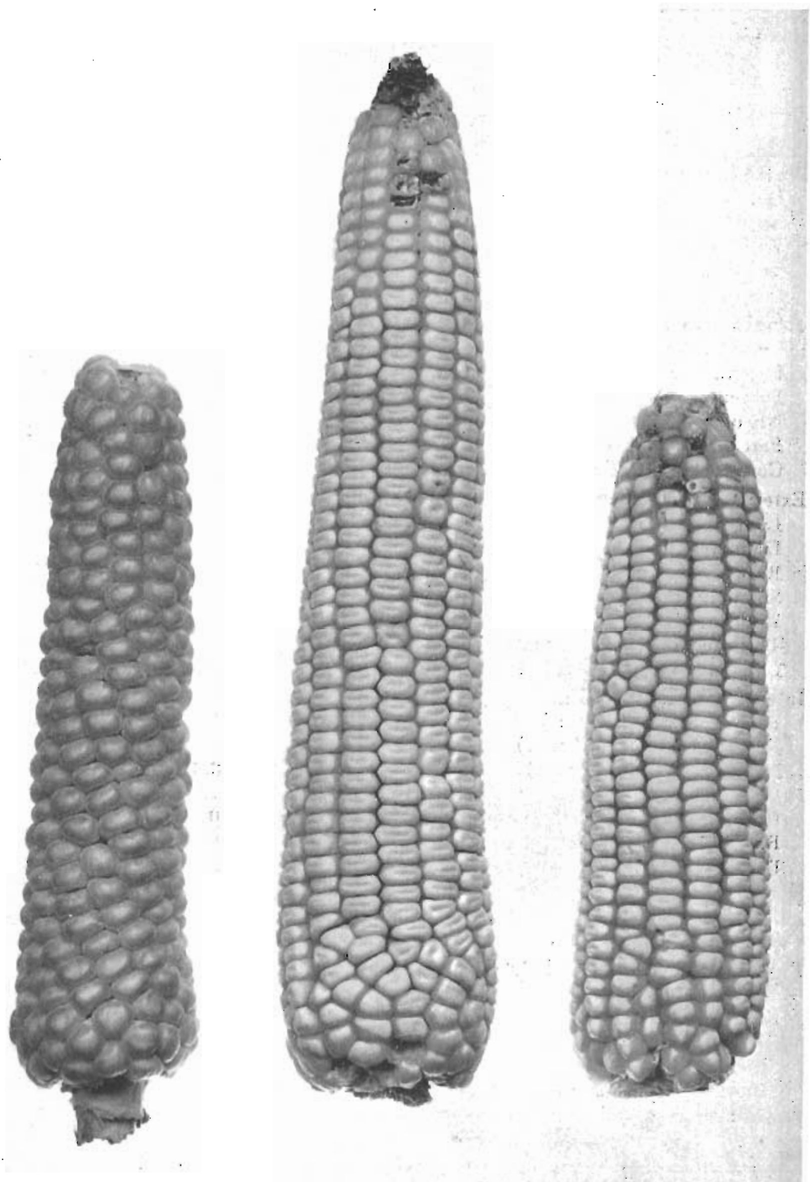


FIG. 63. Origin of Comiteco. Comiteco is intermediate in most of its characteristics between Olotón and Tehua, two races more widely distributed in Guatemala than in Mexico. Left to right (1) Olotón, (2) Comiteco and (3) Tehua. Scale 1 cm. = 1.99 cm.

TABLE 3. Comparison of Comiteco With Its Probable Progenitors, Olotón and Tehua.

	Olotón	*Comiteco*	*Tehua*
Plant Characters			
Height (meters)	2.5	3.1	3.3
No. of Leaves	16.0	20.0	20.5
Width of Leaves (cm.)	9.0	10.5	8.7
Length of Leaves (cm.)	—	—	—
Venation Index	2.89	2.79	3.22
Tassel Characters			
Length (cm.)	46.8	39.6	43.0
Length of Branching Space (cm.)	13.0	13.7	16.9
Percent of Branching Space	28.0	35.0	40.0
No. of Branches	16.8	21.3	27.7
Percent Secondary Branches	23.5	18.3	21.1
Condensation Index	1.27	1.22	1.33
External Characters of Ear			
Length (cm.)	18.3	28.7	19.1
Diameter (cm.)	4.3	5.2	5.7
Row Number	11.7	13.5	17.0
Shank Diameter (mm.)	17.7	22.6	21.5
Width of Kernel (mm.)	9.7	9.5	9.1
Thickness of Kernel (mm.)	6.0	4.5	3.9
Length of Kernel (mm.)	11.2	13.7	11.6
Internal Characters of Ear			
Diameter of Cob (mm.)	27.7	34.5	42.0
Diameter of Rachis (mm.)	14.3	18.5	27.5
Length of Rachilla (mm.)	3.0	3.3	2.9
Cob/rachis Index	1.94	1.86	1.53
Glume/kernel Index	0.60	0.58	0.63
Rachilla/kernel Index	0.27	0.24	0.25
Pedicel Hairs	2–3	2–3	3–4
Rachis Flap	1–3	3	1–2
Rachis Induration	1	1	1+
Teosinte Introgression	2	2+	2
Physiological, Genetic and Cytological Characters			
No. Days to Anthesis	108	137	169
Rust Resistance	1	1–2	2
Pilosity	2–3	1	1
Sheath Color	1–2	1–2	0–1
Mid-cob Color, Percent	—	4	45
Chromosome Knobs, Range	—	3–8	6–8
Average No.	5.0	5.6	7.0

JALA

Plants. Very tall, averaging 4–5 meters in its native habitat; very late maturing; leaves medium in number, narrow, very long in relation to their width; medium venation index; leaf sheaths

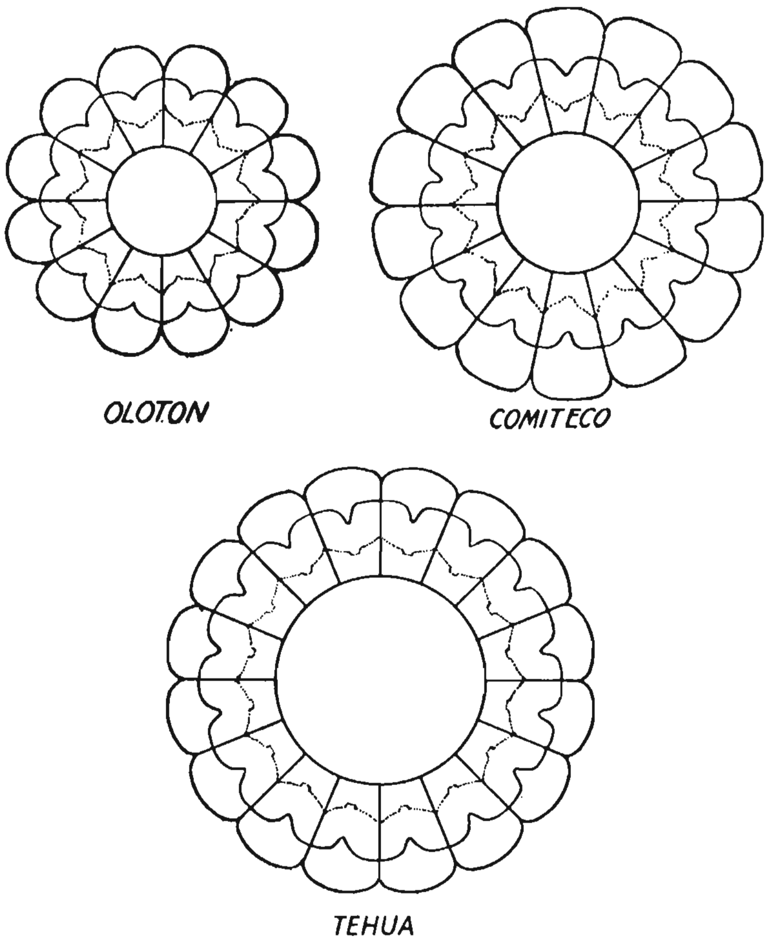


FIG. 64. A comparison of the diagrammatic ear cross sections of Olotón, Comiteco and Tehua.

slightly pubescent, without sun-red color; medium resistance to rust; medium knob number, average 7.5. Adapted to medium elevations, about 1,000 meters.

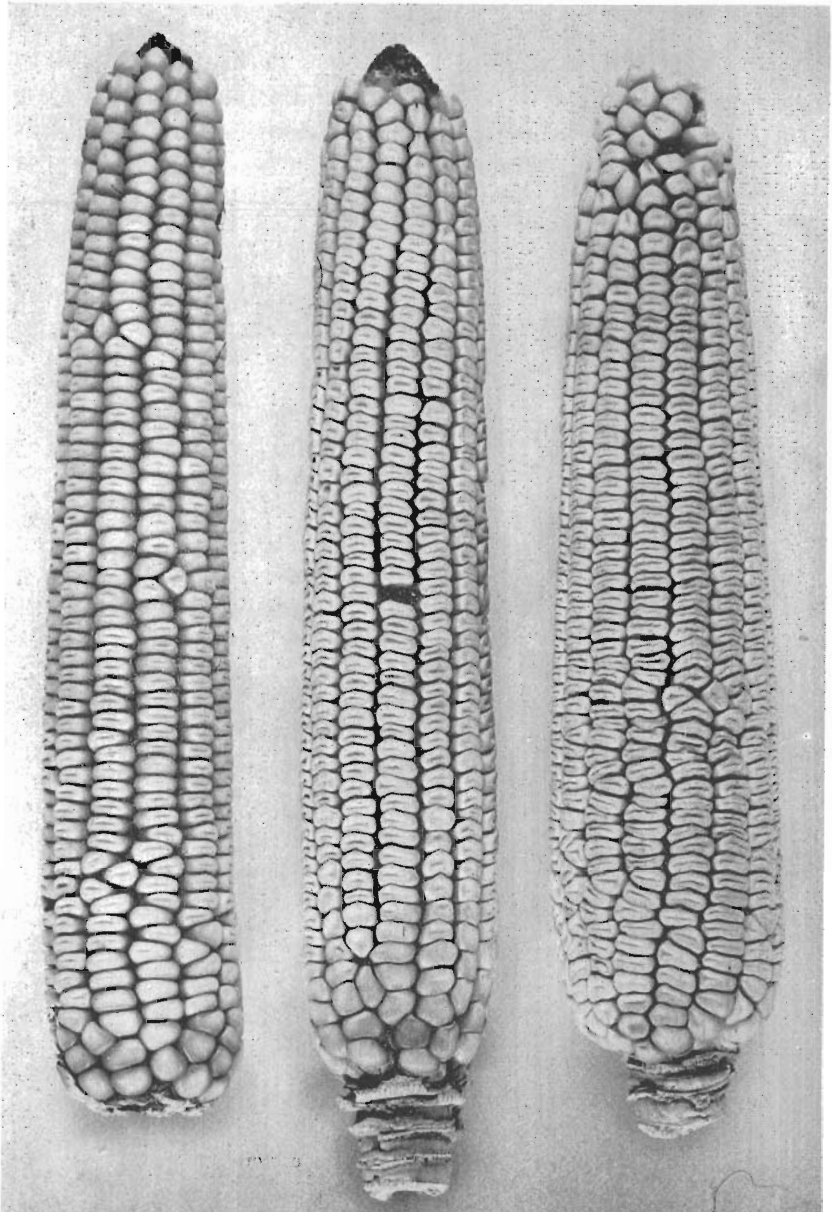
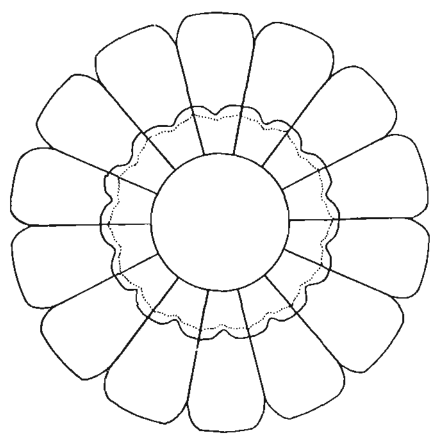


FIG. 65. Jala. The ears of Jala are the largest found in any Mexican race and the plants are extremely tall and late. This race in pure form is found only in a very small area, the Jala valley of Nayarit. Scale 1 cm. = 2.23 cm.

Tassels. Long, highly branched, average number 17.9 per tassel, arising from 35% the length of the central spike; secondaries common; tertiaries absent.

Ears, External Characters. (Fig. 65) Very long, broad, cylindrical ears with a medium row number; shank diameter largest of races. Kernels very large, broad, thick and long, denting pronounced; striations slight; endosperm white, medium hard; aleurone and pericarp colorless.

Ears, Internal Characters. (Fig. 66) Ear diameter 55–59 mm.; cob diameter 24–32 mm.; rachis diameter 18 mm.; kernel length



JALA

FIG. 66.

14.2 mm.; estimated rachilla length 4.3 mm.; cob/rachis index low, 1.56; glume/kernel index low, 0.35; rachilla/kernel index high, 0.30; pedicel hairs long, few to intermediate in number; cupule hairs intermediate to many, short to long; rachis flap strong; lower glumes horny, surface hairs few or none, marginal hairs long, few to intermediate in number; upper glumes fleshy to horny, stiff, no venation, surface hairs few or none, marginal hairs few short, margins broadly cordate; tunicate allele tu^w; rachis tissue horny to long; teosinte introgression strong.

Distribution. Jala in its pure form is seldom found except in the small Jala valley of southern Nayarit. This valley has an elevation of approximately 1,000 meters and apparently offers a combination of environmental factors such as fertile soil, ample moisture, and fairly high temperatures especially suited to the exacting demands of this very late, tall-growing corn. Because this race is outstanding in its general vigor and especially in size of ear when grown in the Jala valley, numerous attempts have been made to introduce it into other regions of Mexico, but these have met with disappointing results. Jala can occasionally be encountered growing in the region of Lake Chapala, near Guadalajara, Jalisco where the elevation is approximately 1,500 meters and the environmental

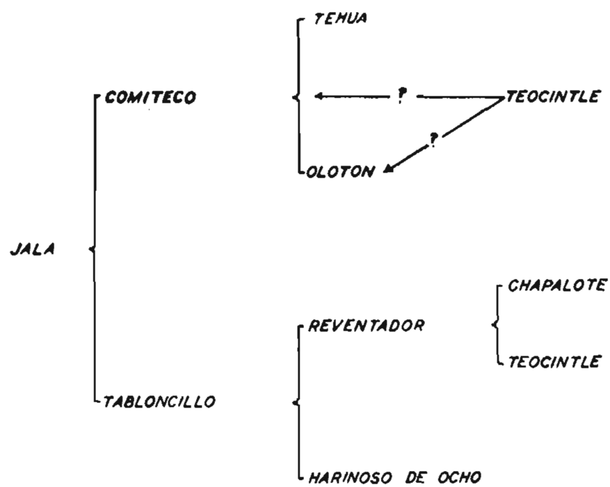


Fig. 67. The probable origin of Jala.

conditions are somewhat similar to those of the Jala valley. There is some evidence that in the Chapala region there has been a slight degree of introgression of this race into some of the local varieties. The distribution of Jala is shown in Fig. 61.

Origin and Relationships. Jala is probably a derivative of Comiteco, modified by an introgression of genes from Tabloncillo and with some of the characteristics of one or the other parent accentuated by the special environment in which Jala has evolved. Its suggested genealogy is given in Fig. 67.

That Jala is more similar to Comiteco than to Tabloncillo is shown by data presented in Table 4 and by a comparison of typical ears of the three races shown in Fig. 68. Jala exhibits giant plants that are very late in maturity, which is characteristic of

TABLE 4. Comparison of Jala With Its Probable Progenitors, Comiteco and Tabloncillo.

	Comiteco	*Jala*	*Tabloncillo*
Plant Characters			
Height of Plant (meters)	3.1	3.1	2.4
No. of Leaves	20.0	14.4	14.6
Width of Leaves (cm.)	10.5	7.8	8.6
Length of Leaves (cm.)	—	82.3	79.8
Venation Index	2.79	2.94	3.56
Tassel Characters			
Length (cm.)	39.6	39.5	40.0
Length of Branching Space (cm.)	13.7	11.1	9.0
Percent of Branching Space	35.0	35.0	23.0
No. of Branches	21.3	17.9	8.8
Percent Secondary Branches	18.3	12.3	11.5
Condensation Index	1.22	—	1.10
External Characters of Ear			
Length (cm.)	28.7	30.5	16.4
Diameter (cm.)	5.2	5.9	4.1
Row Number	13.5	14.7	9.1
Shank Diameter (mm.)	22.6	34.5	11.0
Width of Kernel (mm.)	9.5	10.9	11.5
Thickness of Kernel (mm.)	4.5	4.6	4.3
Length of Kernel (mm.)	13.7	14.2	10.3
Internal Characters of Ear			
Diameter of Cob (mm.)	34.5	28.0	23.4
Diameter of Rachis (mm.)	18.5	18.0	12.5
Length of Rachilla (mm.)	3.3	4.3	2.1
Cob/rachis Index	1.86	1.56	1.87
Glume/kernel Index	0.58	0.35	0.53
Rachilla/kernel Index	0.24	0.30	0.20
Pedicel Hairs	2–3	2–3	0–4
Rachis Flap	3	3	2–3
Rachis Induration	1	2	2
Teosinte Introgression	2+	3	2–3
Physiological, Genetic and Cytological Characters			
No. Days to Anthesis	137	134	107
Rust Resistance	1–2	2	1–2
Pilosity	1	1	1
Sheath Color	1–2	0	0–1
Mid-cob Color, Percent	4	—	54
Chromosome Knobs, Range	3–8	7–8	5–9
Average No.	5.6	7.5	7.6

Comiteco, and its massive ears are even larger than those of Comiteco though bearing marked similarities to them, both in external and internal characteristics. The greater resemblance of Jala to Comiteco also can be easily observed in the diagrammatic cross sections in Fig. 69.

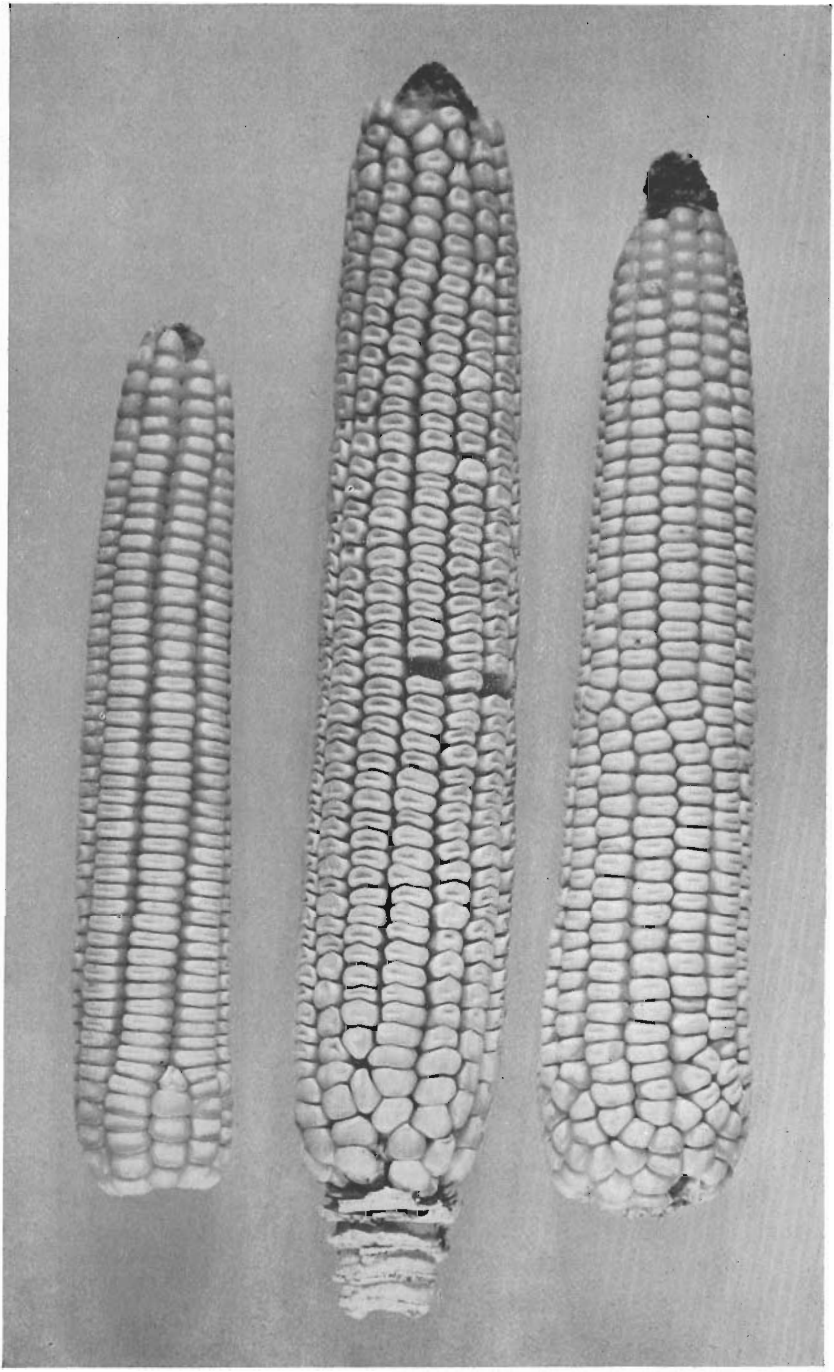


Fig. 68. Origin of Jala. Jala (center) is probably a derivative of the introgression of Tabloncillo (left) into Comiteco (right). Scale 1 cm. = 2.04 cm.

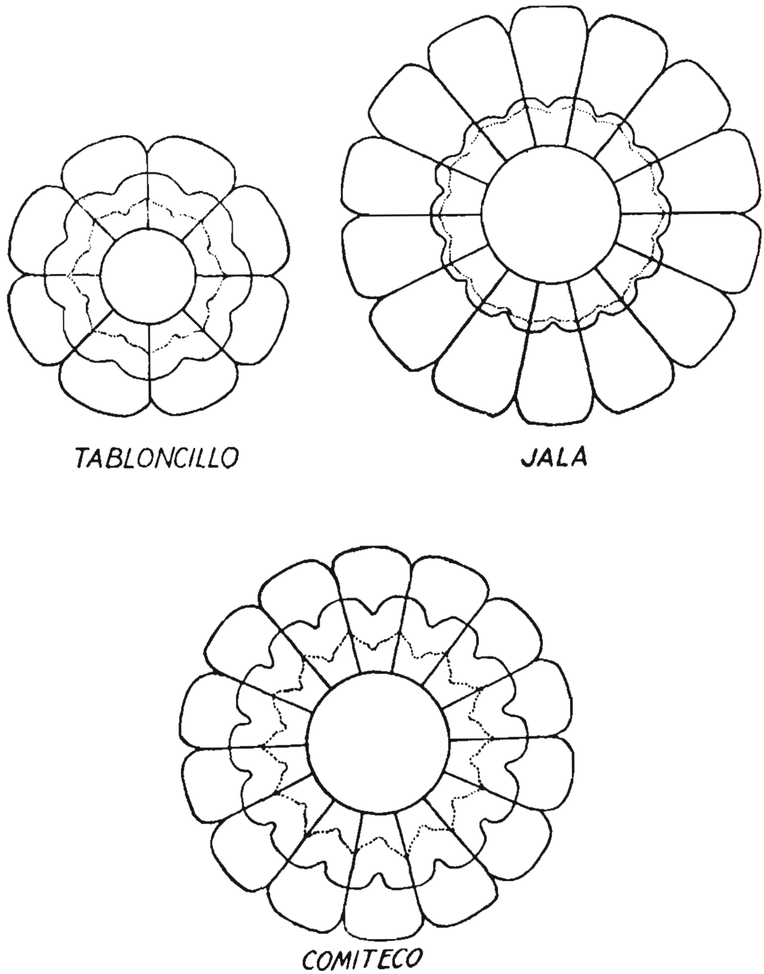


FIG. 69. A comparison of the diagrammatic ear cross sections of Tabloncillo, Jala and Comiteco.

Although Jala is more closely related to Comiteco than to Tabloncillo in the sum total of all the characters studied, there are several characteristics in which Jala is intermediate and still others in which it very closely approaches those of Tabloncillo, as can be observed in Table 4. In internode patterns (Plate VII) Jala tends to be intermediate. Furthermore, ears approaching Tabloncillo quite closely in type can be isolated from Jala upon inbreeding.

There is little reason to doubt, therefore, that Jala has been derived from the introgression of Tabloncillo into Comiteco, or a race of maize very closely resembling Comiteco. Comiteco has not been collected in the part of western Mexico in which Jala now occurs but as mentioned before there is evidence of an introgression of genes from Olotón, one of the putative parents of Comiteco, into some of the varieties of western Mexico, which suggests the possibility that the range of Comiteco, like that of Olotón, might once have been wider than it now is. Tabloncillo is found at present in the same localities with Jala.

The only evidence that Jala is pre-Columbian derives from the fact that it has become a stable and highly specialized race well adapted to a single valley. Since local adaptation in maize varieties sometimes occurs in a relatively short time, and since Jala has had little if any influence upon other varieties, it is quite possible that Jala is actually a comparatively recent development. Additional evidence may, therefore, later place it among the modern instead of the pre-Columbian races, where we now include it.

Derivation of Name. From the name of the valley in the state of Nayarit where this race is grown almost exclusively.

References. Kempton, 1924.

ZAPALOTE CHICO

Plants. Very short, usually from 1–2 meters in height; very early in maturity; few tillers; leaves few with high venation index; purple plant color fairly common with slight amount of sun-red; pubescence slight to absent; highly susceptible to rust; knob number high, averaging 11.7. Adapted to low elevation, about 100 meters.

Tassels. Very short, high number of branches arising from more than one-third the length of the main axis; secondaries frequent; tertiaries absent; condensation index medium high.

Ears, External Characters. (Fig. 70) Extremely short; 10–12 rows; shank diameter very large especially in relation to size of ear; thickest husk covering of all Mexican races; mid-cob color in 18% of ears examined; kernels short, medium wide and medium thick, well dented; shells easily and shatters frequently because the kernels are almost out of the glumes (Fig. 71); striations absent; endosperm white and mostly soft starch; aleurone and pericarp colorless.

Ears, Internal Characters. (Fig. 71) Ear diameter 40–44 mm.; cob diameter 21–26 mm.; rachis diameter 13–16 mm.; kernel length 10–11 mm.; estimated rachilla length 3.7 mm.; cob/rachis index low, 1.66; glume/kernel index low, 0.46; rachilla/kernel index highest of races, 0.37; pedicel hairs none to few, short; cupule hairs variable, mostly long; rachis flap weak; lower glumes

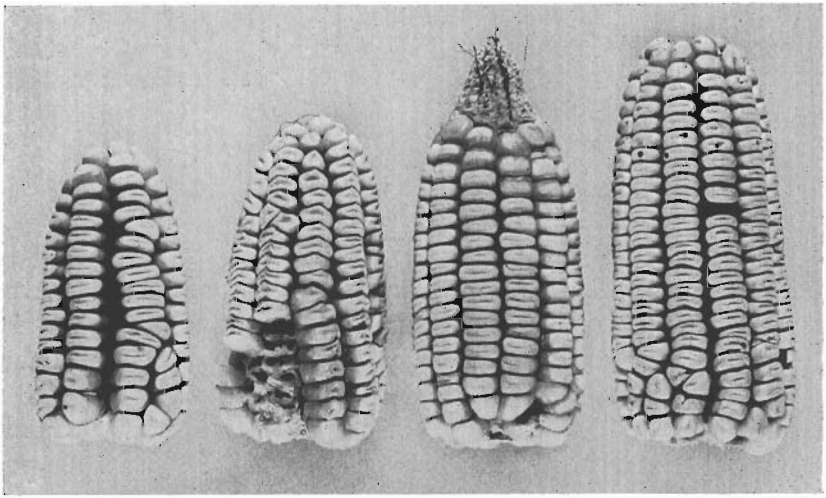


FIG. 70. Zapalote Chico. Representative ears of this race are very short with a low row number and are provided with the maximum husk protection of any race that has been found. Because of the long rachillas and the relatively short glumes, the kernels shatter easily. The plants are very short and early and have considerable color. Scale 1 cm. = 1.95 cm.

fleshy, few short surface hairs, few marginal hairs, the margins angulate; upper glumes fleshy, stiff, few short surface hairs, few short marginal hairs; tunicate alleles *tu* and tu^w; rachis tissue horny to bony; teosinte introgression strong.

Distribution. The distribution of the purest varieties of Zapalote Chico is shown by the black circles in Fig. 54. It is fairly prevalent in the coastal lowlands of Oaxaca and Chiapas, at elevations of about 100 meters. The performance of this race in our experimental plantings at higher elevations indicates that it can probably be found growing in this general region at altitudes up to 1,000 meters. It has been collected in Oaxaca near Niltepec, Reforma, Pochutla and Tehuantepec. Samples collected in Chiapas are from Escuintla. Although not indicated on the map (Fig. 54), its in-

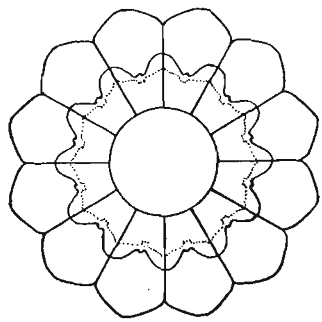


Fig. 71.

fluence on the varieties in southern Guerrero around Arcelia, Altamirano, Petatlan, Xelitla and Mazatlan is strongly evident. Its influence is also strong around Huetamo and Tiquicheo in Michoacán at about 300 meters elevation.

Origin and Relationships. Zapalote Chico is almost certainly the product of hybridization between Nal-Tel, the primitive pop

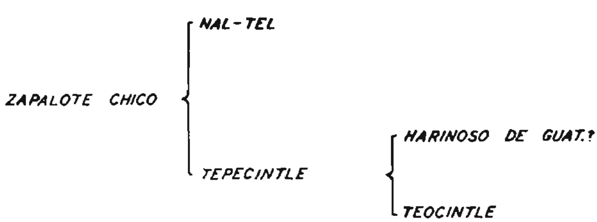


Fig. 72. The probable origin of Zapalote Chico.

corn of southern Mexico, and another race, probably Tepecintle. Its postulated genealogy is given in Fig. 72. The distribution of these two putative parents overlap (Figs. 10 and 57) in the area where Zapalote Chico is most common. Zapalote Chico is similar to Nal-Tel (Table 5) in plant type, tassel length, number of

TABLE 5. Comparison of Zapalote Chico With Its Probable Progenitors, Nal-Tel and Tepecintle.

	Nal-Tel	*Zapalote Chico*	*Tepecintle*
Plant Characters			
Height (meters)	1.3	1.2	1.8
No. of Leaves	12.0	10.0	13.6
Width of Leaves (cm.)	8.7	7.9	10.0
Length of Leaves (cm.)	65.6	64.2	85.7
Venation Index	3.03	3.30	2.88
Tassel Characters			
Length (cm.)	32.7	34.0	41.5
Length of Branching Space (cm.)	11.8	10.7	14.4
Percent of Branching Space	30.0	34.0	34.0
No. of Branches	22.8	18.9	24.7
Percent Secondary Branches	30.0	16.0	21.5
Condensation Index	1.00	1.72	1.08
External Characters of Ear			
Length (cm.)	7.9	9.9	10.4
Diameter (cm.)	2.7	4.2	4.9
Row Number	11.4	10.7	11.8
Shank Diameter (mm.)	7.1	13.7	10.8
Width of Kernel (mm.)	6.7	9.8	9.1
Thickness of Kernel (mm.)	3.9	3.6	3.7
Length of Kernel (mm.)	7.4	10.1	11.9
Internal Characters of Ear			
Diameter of Cob (mm.)	19.2	23.3	32.8
Diameter of Rachis (mm.)	9.2	14.0	20.5
Length of Rachilla (mm.)	1.6	3.7	3.3
Cob/rachis Index	2.09	1.66	1.60
Glume/kernel Index	0.68	0.46	0.52
Rachilla/kernel Index	0.22	0.37	0.28
Pedicel Hairs	0	0–1	0
Rachis Flap	2–3	1	1–3
Rachis Induration	1	1–2	1–2
Teosinte Introgression	0–1	3	4
Physiological, Genetic and Cytological Characters			
No. Days to Anthesis	105	96	113
Rust Resistance	4	4–5	4
Pilosity	1	0–1	1
Sheath Color	1	2	2
Mid-cob Color, Percent	0	18	42
Chromosome Knobs, Range	4–7	10–14	6–11
Average No.	5.5	11.7	9.0

branches and length of branching space. It is almost identical with Nal-Tel in internode pattern (Plate VII). It also approaches Nal-Tel in number of days to maturity. They are both early corns. Zapalote Chico, like Nal-Tel, because of its early maturity is well adapted to regions of low rainfall such as the coastal areas of

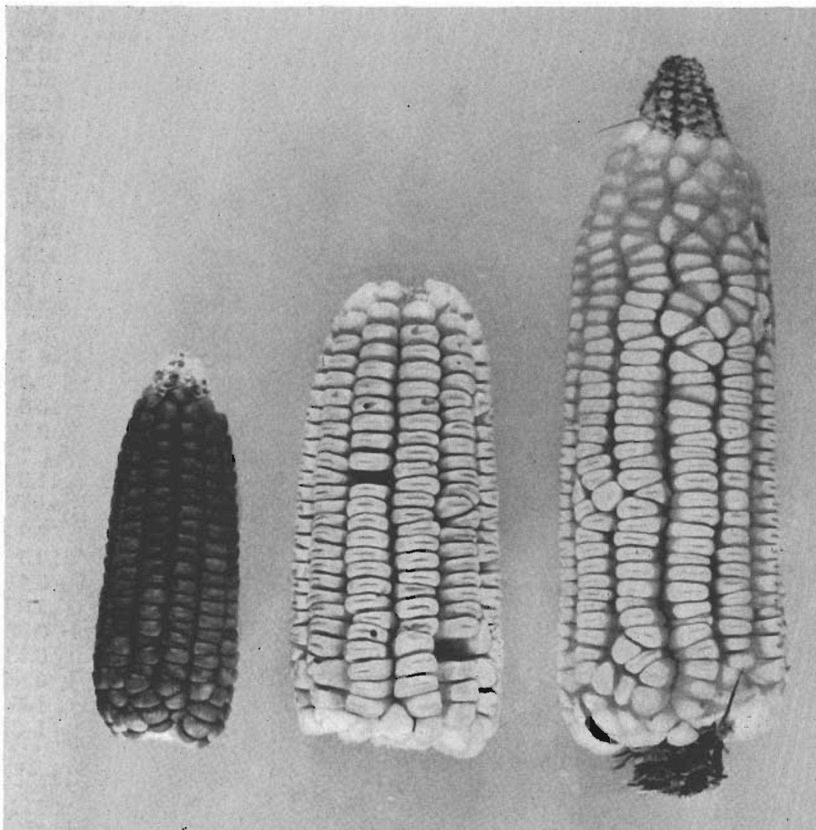


FIG. 73. Origin of Zapalote Chico. Zapalote Chico (center) is thought to have originated from a natural cross between Nal-Tel (*left*), the primitive pop corn of Southern Mexico, and Tepecintle (right) the high-knob cylindrical dent of Southern Mexico and Guatemala. Scale 1 cm. = 1.74 cm.

southern Oaxaca. Furthermore, it is similar to Nal-Tel in its adaptation to tropical soils fairly low in nitrogen. In many of the external and internal characters of the ears Zapalote Chico is either intermediate or resembles Tepecintle (Table 5). The close relationship to both parents in characters of the ears is very clearly shown in Fig. 73 and in the cross-section diagrams (Fig. 74). It differs from either parent in its slightly lower row number, its unusually long rachilla and high chromosome knob number. The

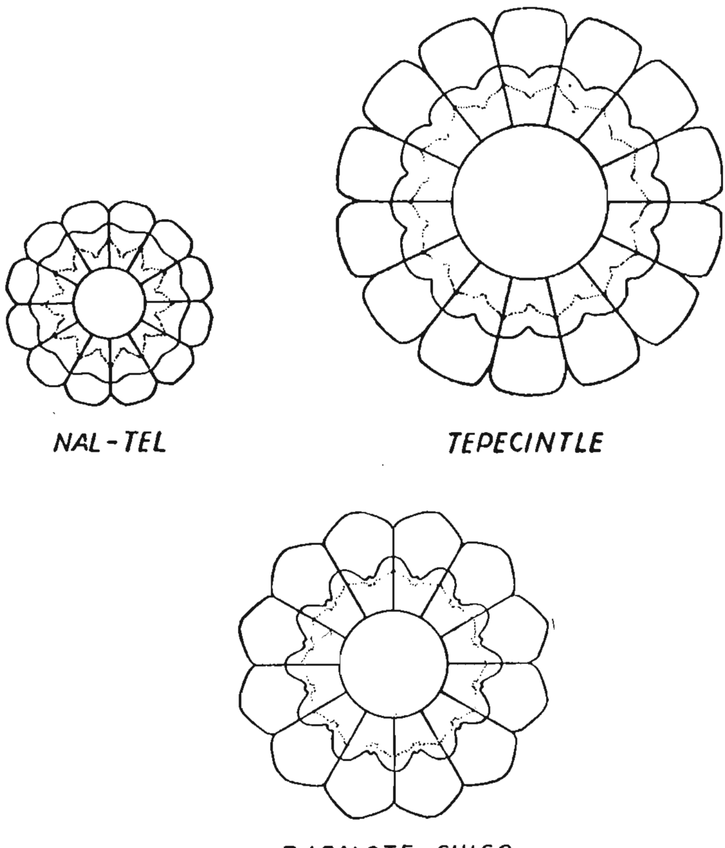


FIG. 74. A comparison of the diagrammatic ear cross sections of Nal-Tel, Zapalote Chico and Tepecintle.

chromosome knob number is easily accounted for since the original Tepecintle of Guatemala (Mangelsdorf and Cameron, 1942) has knob numbers ranging from 12 to 16 but the reason for the extreme rachilla length and slightly lower row number is not clear. Nevertheless, the hybridization of Tepecintle (or something similar to it) and Nal-Tel is the best explanation now available for the origin of Zapalote Chico. Since Zapalote Chico is undoubtedly involved in the origin of Zapalote Grande which in turn has been the parent of secondary races, it must be of relatively ancient origin.

Derivation of Name. Zapalote is the name commonly used for this race and the one following in the Isthmus of Tehuantepec. Its

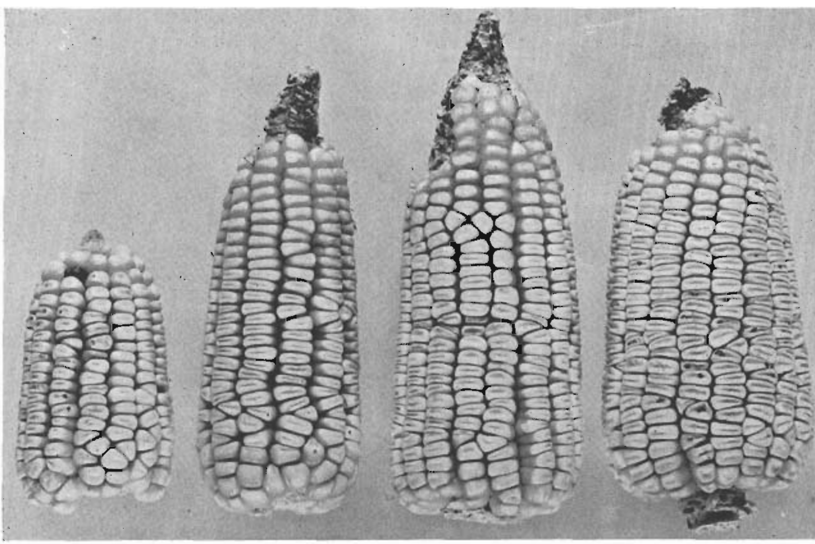


FIG. 75. Zapalote Grande. The similarities between these representative ears of Zapalote Grande and those of Zapalote Chico are readily apparent. The ears are larger with a higher row number and the plants are more vigorous and later in maturity. Scale 1 cm. = 2.47 cm.

derivation is unknown. Since Zapalote Chico and Zapalote Grande, the following race described, differ primarily in size of ear and plant the two are distinguished by calling the present one "Chico" meaning small and the other "Grande" meaning large.

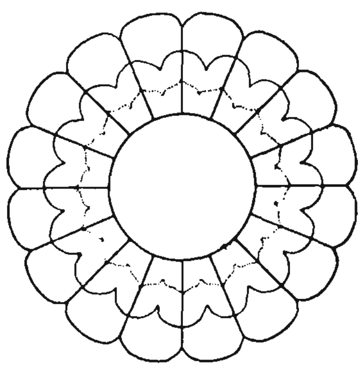
ZAPALOTE GRANDE

Plants. Short, 1.5 to 2.5 meters in native habitat; medium maturity; few tillers; number of leaves medium; venation index medium; some purple plant color but very slight sun-red; slight pubescence; highly susceptible to rust; medium number of knobs, average 7.4. Adapted low elevations, about 100–600 meters.

Tassels. Medium long, many branches, numerous secondaries, tertiaries absent; condensation index medium.

Ears, External Characters. (Fig. 75) Short, broad, cylindrical except for slight taper near the tip; average number of rows 15.7; very thick shank; mid-cob color absent. Kernels short, wide, thin; shallow to medium deep denting; striations absent; endosperm medium soft texture, white; aleurone and pericarp colorless.

Ears, Internal Characters. (Fig. 76) Ear diameter 44–49 mm.; cob diameter 29–34 mm.; rachis diameter 17–22 mm.; kernel length 10–13 mm.; estimated rachilla length 2.7 mm.; cob/rachis index low, 1.64; glume/kernel index medium, 0.55; rachilla/kernel index



ZAPALOTE GRANDE

FIG. 76.

medium, 0.24; pedicel hairs few intermediate to long; cupule hairs few of intermediate length; rachis flap weak; lower glumes fleshy to horny, mostly glabrous with few marginal hairs of intermediate length, margins luniform; upper glumes chaffy, stiff, few short surface hairs, few short marginal hairs; tunicate alleles tu^w and higher; rachis tissue horny to bony; teosinte introgression intermediate to strong.

Distribution. Zapalote Grande is found in the same general areas as Zapalote Chico but tends to be adapted to slightly higher altitudes. Its distribution is shown in Fig. 54 by the half white and half black circles. Collections have been made from Reforma and Juchitan in Oaxaca, and Mapastepec, Escuintla, San Felipe, El Paval and Chiapilla in Chiapas, at elevations ranging from 100 to 600 meters. Varieties closely related to Zapalote Grande but with kernels of a more floury texture are common in Chiapas near Acala, Amatenango de la Frontera, Tapitzala and Comalapa at elevations from 500 to 900 meters.

Origin and Relationships. Zapalote Grande is undoubtedly the result of the hybridization between Zapalote Chico and a large-cobbed many-rowed flour corn such as Tehua or its less tripsacoid progenitors. Its proposed genealogy is given in Fig. 77.

As has already been mentioned, a flour corn such as Tehua exists in Chiapas in the same general area as Zapalote Chico but at a higher altitude, and since Zapalote Grande is intermediate in its adaptation between Zapalote Chico and Tehua this interpretation of the origin of Zapalote Grande is entirely plausible. Fur-

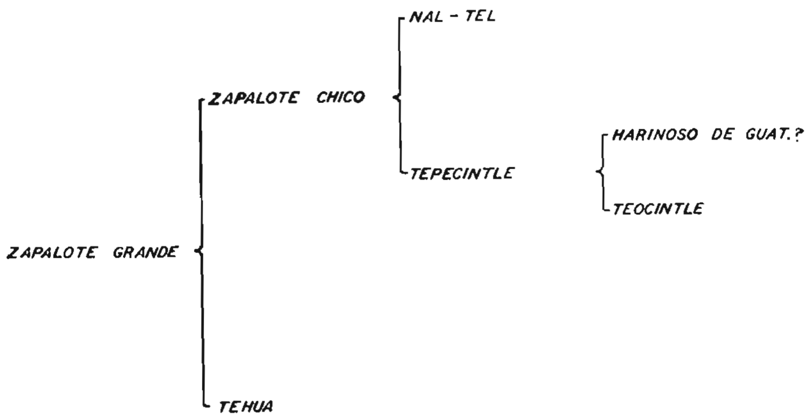


FIG. 77. The probable origin of Zapalote Grande.

thermore, the resemblances of Zapalote Chico to its putative parents are easily seen in the data in Table 6, in the illustrations of the ears in Fig. 78, and in the diagrammatic cross sections of the ears in Fig. 79. Zapalote Grande, as evident in Table 6, is intermediate between Zapalote Chico and Tehua in most of the characters measured or scored. However, in internode pattern (Plate VII) it resembles Zapalote Chico more closely than it does Tehua. Zapalote Grande is somewhat more recent in origin than Zapalote Chico; nevertheless, it appears to have been involved in the ancestry of additional races and must, therefore, itself be regarded as relatively ancient.

Derivation of Name. See Zapalote Chico.

References. Cuevas Ríos, 1947 (as Bola).

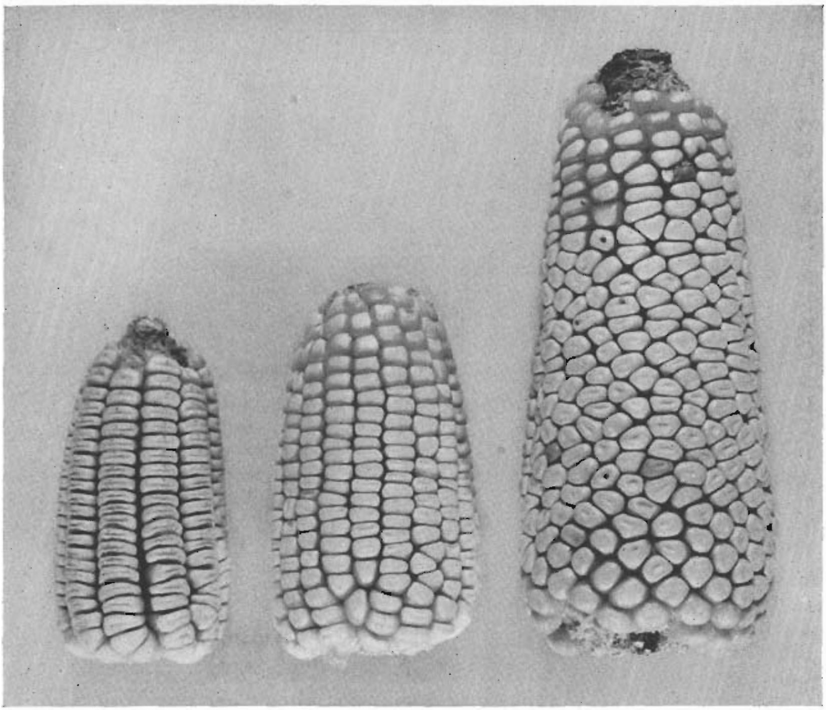


FIG. 78. Origin of Zapalote Grande. Zapalote Grande (center) is undoubtedly a modified type of Zapalote Chico (left). The other parent is not definitely known but shown at the right is large-cobbed, many-rowed flour corn, Tehua, which is thought to have furnished the characters to account for the modification. Scale 1 cm. = 1.97 cm.

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Plants. Medium tall; medium maturity; medium number of tillers; leaves numerous; venation index low; sun-red or purple color very slight to absent; almost glabrous; medium resistance to races of rust; average number of knobs 8.5. Adapted to intermediate elevations, 1,000–1,700 meters.

Tassels. Long, many branches, arising from more than one-third the length of central axis; secondary branches frequent, tertiaries absent; condensation index medium.

TABLE 6. Comparison of Zapalote Grande With Its Probable Progenitors, Zapalote Chico and Tehua.

	Zapalote Chico	*Zapalote Grande*	*Tehua*
Plant Characters			
Height (meters)	1.2	1.6	3.3
No. of Leaves	10.0	15.9	20.5
Width of Leaves (cm.)	7.9	9.6	8.7
Width of Leaves (cm.)	64.2	81.4	—
Venation Index	3.30	2.92	3.22
Tassel Characters			
Length (cm.)	34.0	39.7	43.0
Length of Branching Space (cm.)	10.7	13.0	16.9
Percent of Branching Space	34.0	30.0	40.0
No. of Branches	18.9	23.9	27.7
Percent Secondary Branches	16.0	12.6	21.1
Condensation Index	1.72	1.55	1.33
External Characters of Ear			
Length (cm.)	9.9	14.8	19.1
Diameter (cm.)	4.2	4.9	5.7
Row Number	10.7	15.7	17.0
Shank Diameter (mm.)	13.7	18.1	21.5
Width of Kernel (mm.)	9.8	9.3	9.1
Thickness of Kernel (mm.)	3.6	3.8	3.9
Length of Kernel (mm.)	10.1	11.1	11.6
Internal Characters of Ear			
Diameter of Cob (mm.)	23.3	31.5	42.0
Diameter of Rachis (mm.)	14.0	19.2	27.5
Length of Rachilla (mm.)	3.7	2.7	2.9
Cob/rachis Index	1.66	1.64	1.53
Glume/kernel Index	0.46	0.55	0.63
Rachilla/kernel Index	0.37	0.24	0.25
Pedicel Hairs	0–1	1–2	3–4
Rachis Flap	1	1	1–2
Rachis Induration	1–2	1–2	1+
Teosinte Introgression	3	2–3	2
Physiological, Genetic and Cytological Characters			
No. Days to Anthesis	96	118	169
Rust Resistance	4–5	3–4	2
Pilosity	0–1	1	1
Sheath Color	2	1–2	0–1
Mid-cob Color, Percent	18	0	45
Chromosome Knobs, Range	10–14	6–9	6–8
Average No.	11.7	7.4	7.0

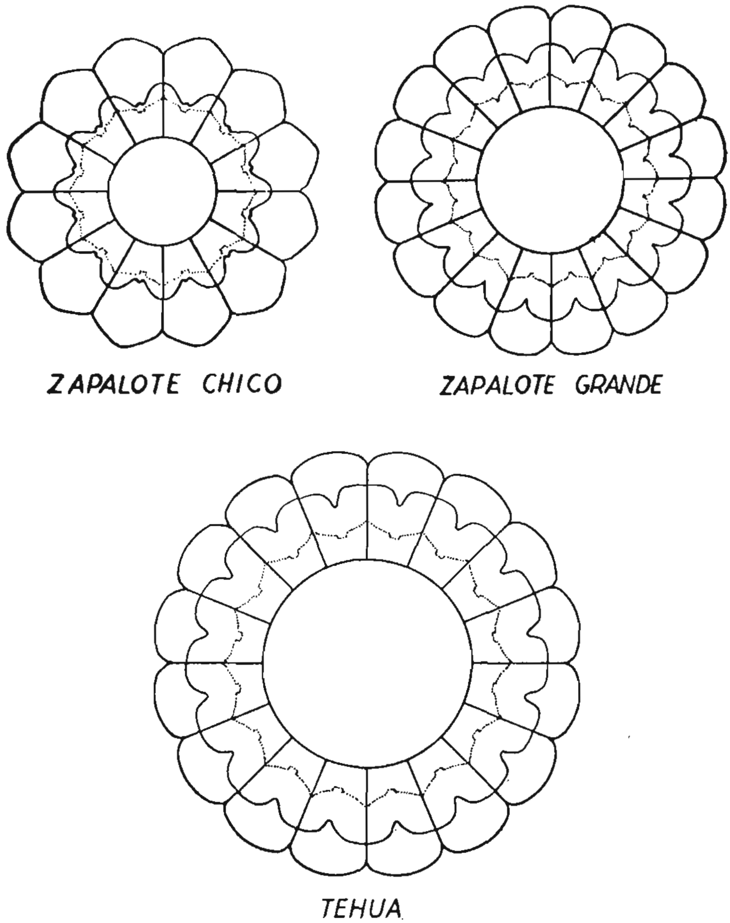


FIG. 79. A comparison of the diagrammatic cross sections of Zapalote Chico, Zapalote Grande and Tehua.

Ears, External Characters. (Fig. 80) Medium long, broad, slight uniform taper from base to tip; average number of rows 15.5; wide space between rows fairly common due to spreading apart of the members of a pair of spikelets; shank diameter medium large; mid-cob color very infrequent, present in only 3% of ears examined; kernels very narrow, thin, and extremely long; apex of kernel terminates in exaggerated point or beak up to 10 mm. in length that projects at near right angle to the long axis of kernel; striations absent; endosperm soft, white; aleurone and pericarp colorless.

Ears, Internal Characters. (Fig. 81) Ear diameter 53–55 mm.; cob diameter 22–28 mm.; rachis diameter 12–13 mm.; kernel length 19–23 mm.; estimated rachilla length 0.4 mm.; cob/rachis

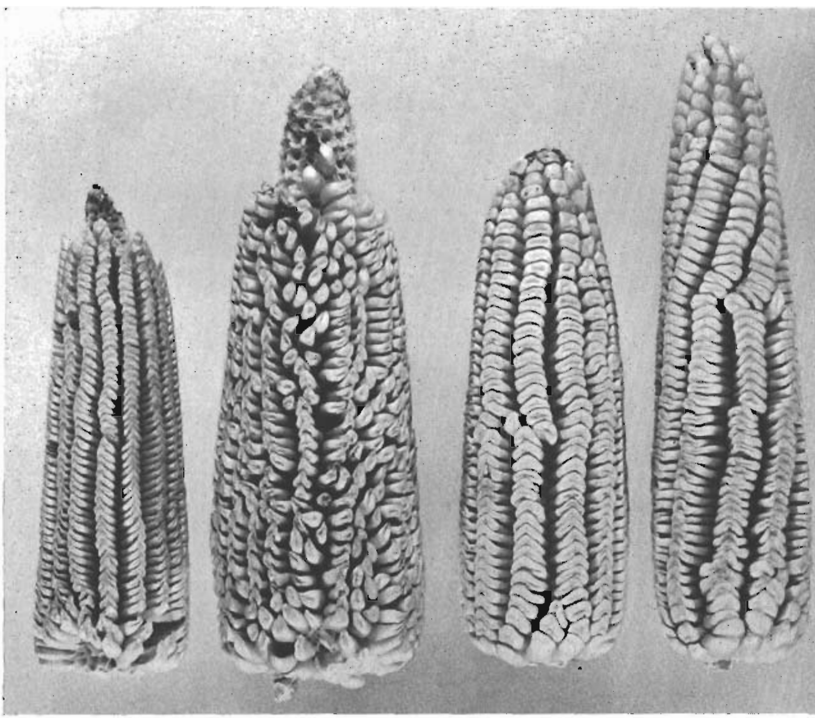
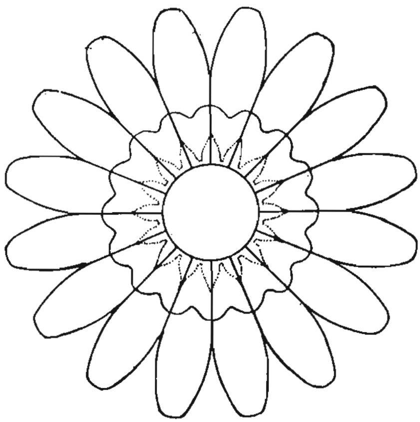


FIG. 80. Pepitilla. The distinctive feature of this race is the extremely long, pointed seeds that are often beaked at the apex. This race is probably related to the "Gourdseed" or "shoepeg" corn of the southern states of the United States. Scale 1 cm. = 2.85 cm.

index high, 2.00; glume/kernel index low, 0.30; rachilla/kernel index very low, 0.02; pedicel hairs none or few long; cupule hairs few, intermediate or long; rachis flap variable, weak to strong; lower glumes fleshy to horny, glabrous to sparsely hairy, marginal hairs variable, margins luniform to slightly angulate; upper glumes fleshy with transparent margins, stiff, glabrous, marginal hairs lacking or few and short; tunicate allele mostly *tu*; rachis tissue horny; teosinte introgression slight to intermediate.

Distribution. Locations of the varieties most typical of this race are shown by the solid black dots in Fig. 82. The center of distribution of the purest forms is in Morelos and northern Guerrero at elevations of 1,000 to 1,500 meters in the upper Balsas River Basin. Varieties which are generally called Pepitilla but which are less extreme in length of kernel and high row number are



PEPITILLA

FIG. 81.

grown extensively throughout north central Guerrero at elevations of 1,000 to 1,700 meters. These have been called semi-Pepitilla and their distribution is shown in Fig. 82 by the circles containing a cross. The semi-Pepitilla types are also found in western Puebla near Atlixco, and in Michoacán and Jalisco in the vicinity of Lake Chapala in the Jaliscan plateau at elevations of 1,200 to 1,500 meters. Varieties showing Pepitilla influence (clear circles, Fig. 82) are widely distributed, ranging from 1,000 to 1,700 meters in elevation, and extending from western Puebla through Guerrero and Michoacán into eastern Jalisco.

Origin and Relationships. Pepitilla is one of the most distinctive Mexican races because of its extremely long narrow pointed seeds that shell easily from the cob, and its very high row number. This race appears to have been derived from a combination of characters from Palomero Toluqueño or its sub-race, Palomero Poblano of the Central Mesa, and some many-rowed tropical dent corn

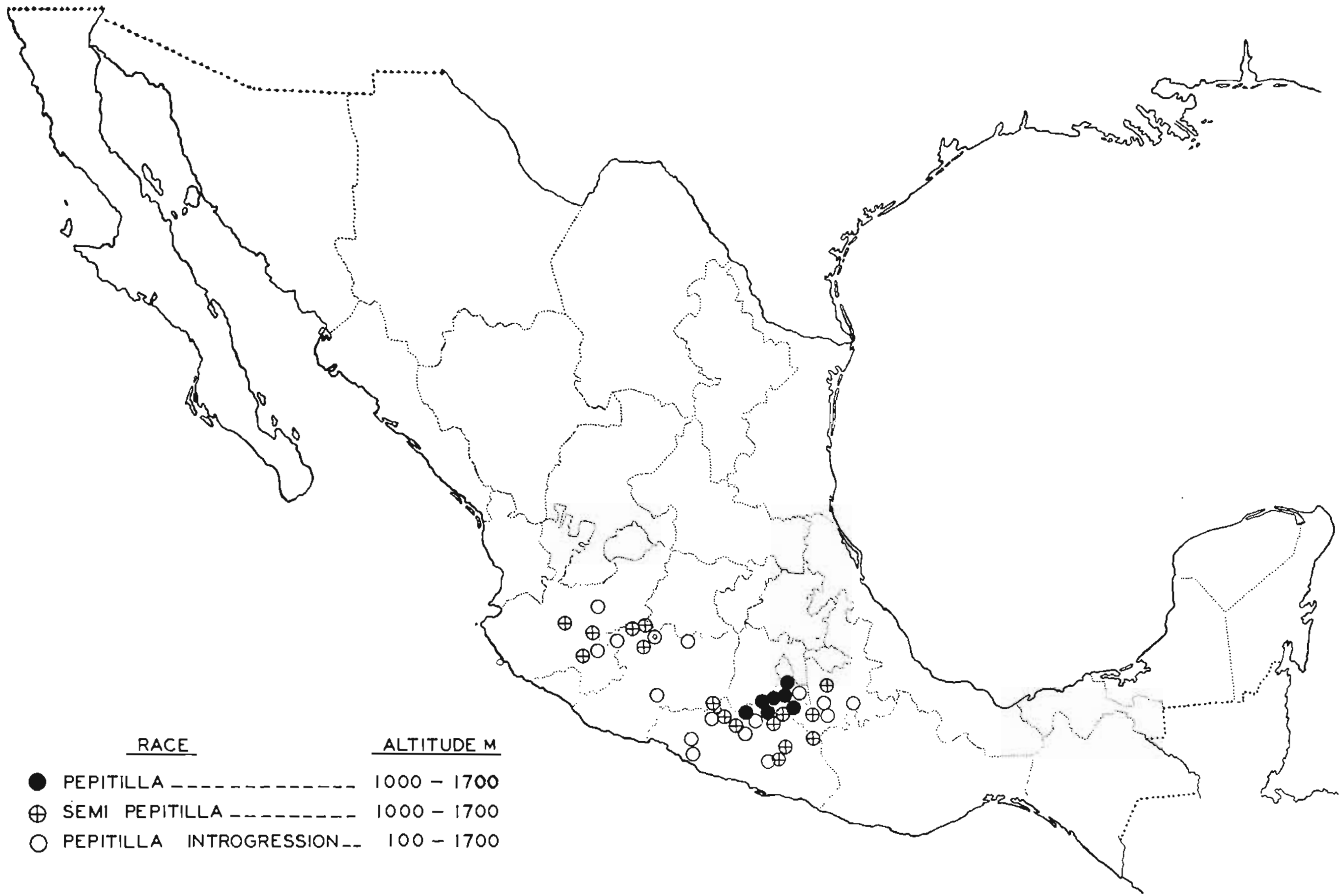


FIG. 82. Distribution of Pepitilla and related types.

possibly Vandeño, to be described later, from the Pacific coastal plains or Balsas River Basin of southern Mexico. Pepitilla, however, goes beyond the range of its putative parents in several characteristics, especially in length of kernels and diameter of the ear, the latter in part the product of the former. It either possesses some genes from a source still unrecognized or it represents a recombination of genes which has resulted in accentuating characteristics contributed by Palomero Toluqueño. The most striking of the characteristics from Palomero Toluqueño are the spreading spikelets and the extremely short rachillae. Pepitilla, as may be readily seen in Plates II and IV and Table 16, has the same extremely short rachilla as Palomero Toluqueño and because its kernels are longer, has an even lower rachilla/kernel index. Although it is fairly certain that Pepitilla acquired many of its characteristics from Palomero Toluqueño, its genealogy at this stage of the investigation is highly speculative and, therefore, is not included. In internode pattern (Plate VII) it is intermediate between Palomero Toluqueño and Vandeño.

Prehistoric remains of Pepitilla are unknown but prehistoric ears from Yampa Canyon in northern Colorado, illustrated by Anderson (1947a) show at least a vague resemblance to it. Pepitilla is also probably related to the "gourd-seed" corn of the southern United States (Brown and Anderson, 1948) and hence must be one of the older races in Mexico.

Derivation of Name. A Spanish name commonly used in the states of Morelos and Guerrero where this kind of corn is generally grown. It refers to the kernels which are similar in shape to squash or pumpkin seeds, "pepita chiquita" or pepitilla.

References. López y Parra, 1908b; Chávez, 1913; Kuleshov, 1930; Anderson, 1946a (within Mexican Pyramidal complex); Bonnett, 1948 (as Mexican long kernel); Brown and Anderson, 1948 (as Shoepeg).

OLOTILLO

Plants. Tall, approximately 3 meters; late maturity; few tillers; very high number of leaves with high venation index; plant color slight to absent; slight pubescence; medium resistance to rust;

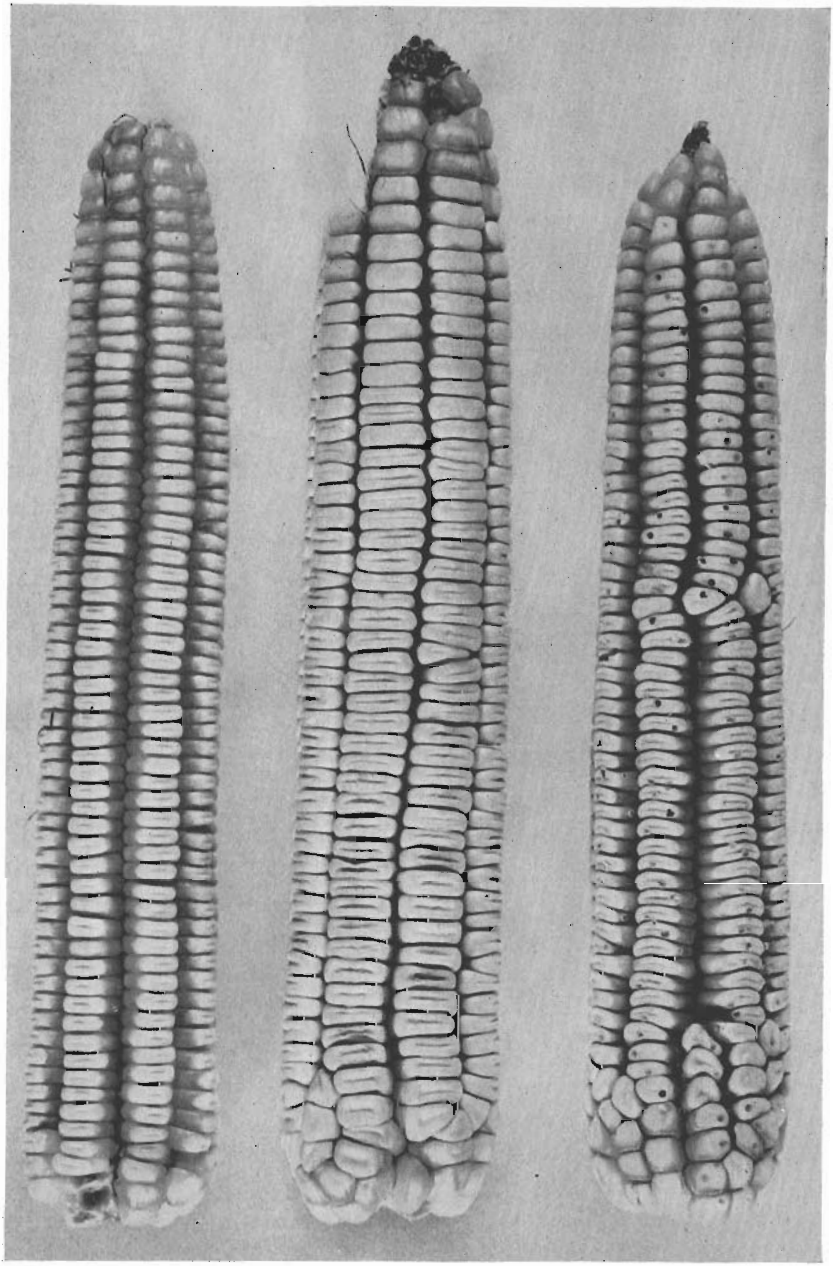
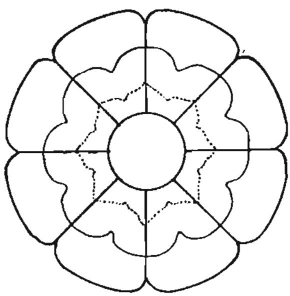


FIG. 83. Olotillo. The extremely tall, late plants of this race produce slender eight-rowed ears whose most distinctive characteristic is a very slender, often-flexible rachis. Scale 1 cm. = 1.38 cm.

medium number of knobs, 6.3. Adapted to low elevations, 300–700 meters.

Tassels. Long, most highly branched of all the races, average 30.3, with branches arising in a long space on the main axis; central spike often lacking or not well defined, in this respect resembling teosinte; secondaries very numerous, tertiaries frequent, condensation very slight to absent.

Ears, External Characters. (Fig. 83) Long, slender, cylindrical; cob flexible; 8–10 rowed; small shank; mid-cob color absent;



OLOTILLO

FIG. 84.

kernels very wide, medium thick, medium short, strongly dented; striations slight. Endosperm mostly soft, white; aleurone and pericarp colorless.

Ears, Internal Characters. (Fig. 84) Ear diameter 36–39 mm.; cob diameter 21–24 mm.; rachis diameter 6–12 mm.; kernel length 11–13 mm.; estimated rachilla length 2.3 mm.; cob/rachis index highest of all races, 2.34; glume/kernel index medium, 0.56; rachilla/kernal index medium, 0.20; pedicel hairs none or few, long; cupule hairs few, long; rachis flap weak; lower glumes horny, few short surface hairs, many long marginal hairs, the margin cordate; upper glumes fleshy, stiff, few short surface hairs, few marginal hairs; tunicate allele tu^w; rachis tissue horny; teosinte introgression strong.

Distribution. The center of distribution of Olotillo is in the Grijalva River Basin in central Chiapas at elevations of 300 to 700 meters, as shown by the solid black circles in Fig. 85. Collections

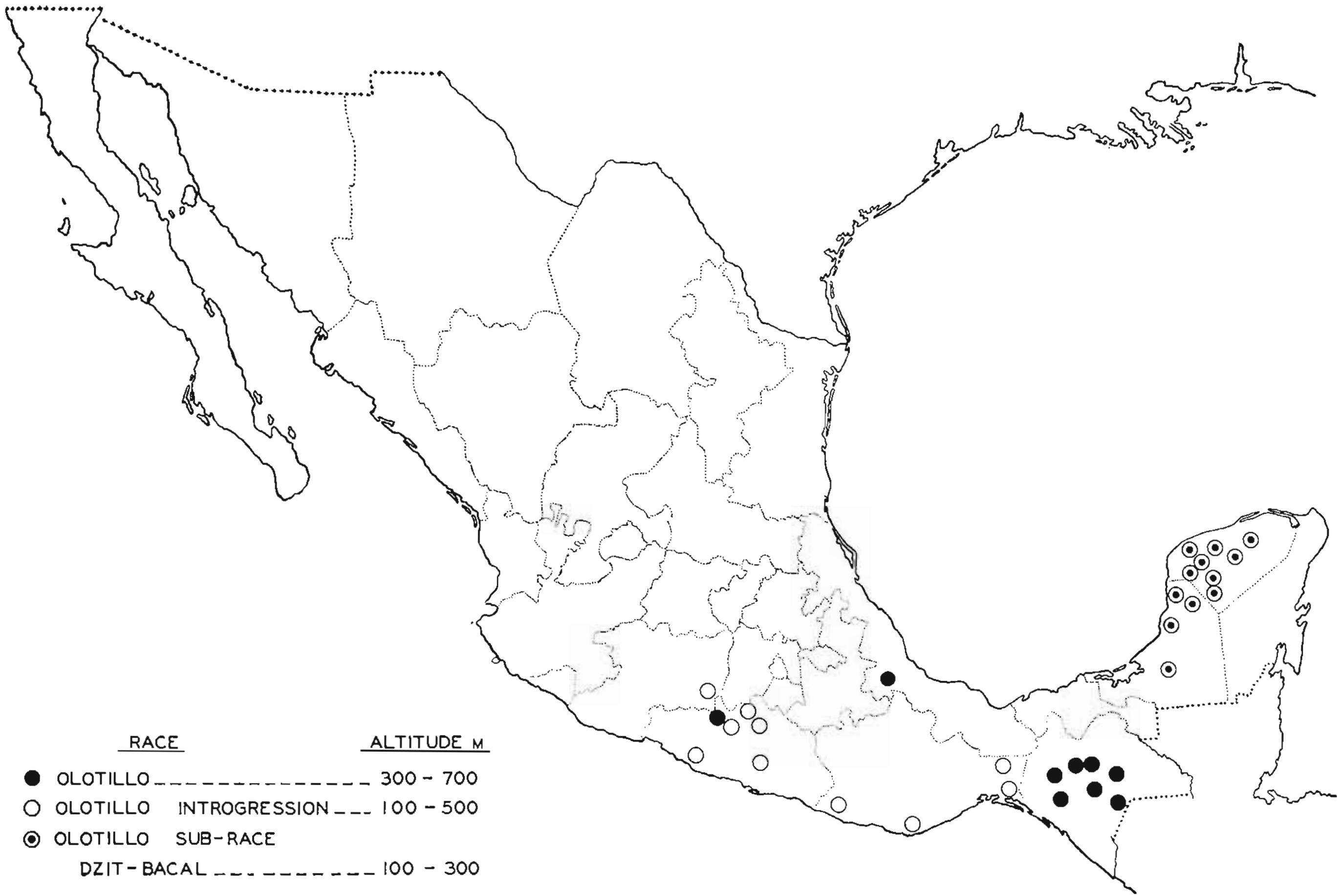


Fig. 85. Distribution of Olotillo, its sub-race Dzit-Bacal, and types showing Olotillo introgression.

were made at Teran, Chiapa de Carzo, Zapotal, Acala and Salvador in Chiapas and from Coyuca de Catalán in northern Guerrero in the Balsas River Basin. Varieties showing strong Olotillo introgression (clear circles, Fig. 85) have been found in the coastal areas of Oaxaca and in the coastal plains and Balsas River Basin of Guerrero, also in that part of the Balsas River Basin extending into Michoacán.

Origin and Relationships. The ancestry of Olotillo is somewhat obscure. In some respects the race is quite tripsacoid. It has a high venation index, its tassel is profusely branched and there is a high percentage of secondary branches. The central spike of the tassel often is not well defined and is quite short in relation to the length of the branching space. In all of these characteristics Olotillo approaches teosinte. The knob number in Olotillo, however, is not as high as it is in several other races, and the rachis tissue is not strongly indurated. We can account for Olotillo only as the product of crossing an eight-rowed flour corn with teosinte or with a race of maize like Tepecintle which already contains teosinte germplasm. However, since crossing with Tepecintle would probably have raised the row number of the hybrid and since Olotillo consistently has low row numbers, there is some reason to believe that Olotillo received its teosinte germplasm directly from teosinte. Teosinte has been reported in Chiapas by Weatherwax (in a conversation) and occurs abundantly in the Department of Huehuetenango in Guatemala which adjoins Chiapas. The other parent of Olotillo is also unknown. That it was an eight-rowed flour corn there is little doubt. It seems probable that this unknown flour corn had a flexible rachis since one of the most distinctive characteristics of Olotillo is its flexible rachis, which could scarcely have been derived from teosinte. All of these facts point to a flexible-cobbed, eight-rowed flour corn as one ancestor of Olotillo. There is no such corn in Mexico today or at least none has been discovered in our studies. We must go to Paraguay and Bolivia to find maize which meets these specifications.[6] It is probable that this flexible eight-rowed flour corn was

[6] The recently discovered eight-rowed Peruvian flour corn described earlier in connection with the origin of Tabloncillo has cobs which are in some cases quite flexible.

related in some way to the eight-rowed flour corn, Harinoso de Ocho, found in northwestern Mexico, but the ancestry of Olotillo must remain something of a mystery until new evidence becomes available. One possible genealogy is postulated in Fig. 86.

Olotillo or something quite similar to it is represented on several Zapotec funeral urns in the National Museum in Mexico (Plate I) as well as on one illustrated by Anderson (1947a). Olotillo has influenced several Mexican races of maize including Tuxpeño, Vandeño, Chalqueño, Celaya and Cónico Norteño. It may also be the source of some of the distinctive characteristics of the United States variety, Hickory King.

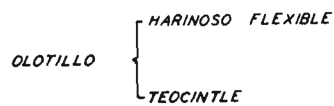


Fig. 86. The probable origin of Olotillo.

Derivation of Name. Common name of this corn in the Grijalva River Basin, Chiapas, where it is extensively cultivated; derived from Nahuatl "olote" meaning cob or rachis of the ear, combined with the Spanish suffix "illo" meaning small; in other words, corn with a small cob.

References. Chávez, 1913 (sub-race Dzit-Bacal from Yucatán); Pérez Toro, 1942 (Dzit-Bacal); Cuevas Ríos, 1947 (Olotillo); Brown and Anderson, 1948 (as Hickory King); Lenz, 1948 (Chiapas 81).

Sub-race of Olotillo
Dzit-Bacal

In the lowlands of Yucatán and Campeche, Olotillo or its precursor became modified by the introgression of Nal-Tel, into a type sufficiently different to be recognized as a sub-race named Dzit-Bacal. This sub-race has its center of distribution quite removed from Olotillo in Chiapas, as shown by the circles with black dots in Fig. 85. A typical ear of Dzit-Bacal is shown at the left in Fig. 83. It differs from the Olotillo of Chiapas in having smaller more flinty kernels, a more flexible cob, no pedicel hairs and is more strongly tunicate and less tripsacoid. Ears intermediate or typical of common varieties resulting from different degrees of introgression of Nal-Tel into Dzit-Bacal or vice-versa may be seen in Fig. 87. Although it may be possible that the extreme flexibility in Dzit-Bacal is due to the restoration of flexibility in the stiffer-cobbed Olotillo of Chiapas by the dilution of the teosinte germplasm through the introgression of Nal-Tel, it is more probable

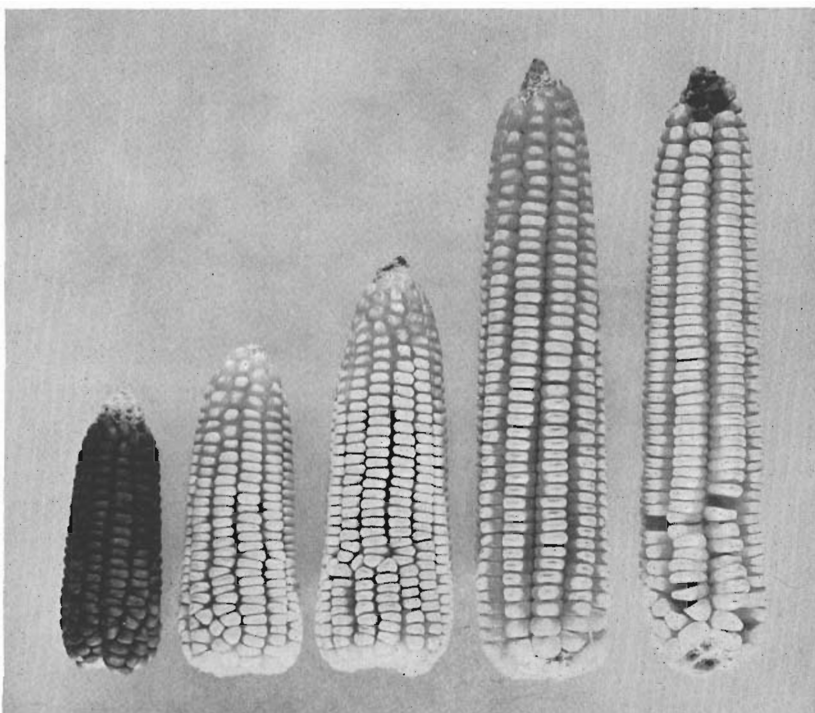


FIG. 87. Introgression of Nal-Tel into Olotillo. The flexible rachis of Olotillo reaches its maximum expression in the sub-race Dzit-Bacal (extreme right). This sub-race is Olotillo *modified through the introgression of* Nal-Tel (extreme left). Varying degrees of this introgression are shown in the other three ears. Scale 1 cm. = 2.39 cm.

that Dzit-Bacal originated from the introgression of Nal-Tel into the precursor of Olotillo directly and that its flexibility was inherited directly from the putative flexible-cobbed precursor. If the precursor of Olotillo was introduced as a non-tripsacoid flexible eight-rowed flour corn, it must have come in contact with Nal-Tel before acquiring many teosinte genes since Nal-Tel was one of the primitive races of the area. Some of the eight-rowed

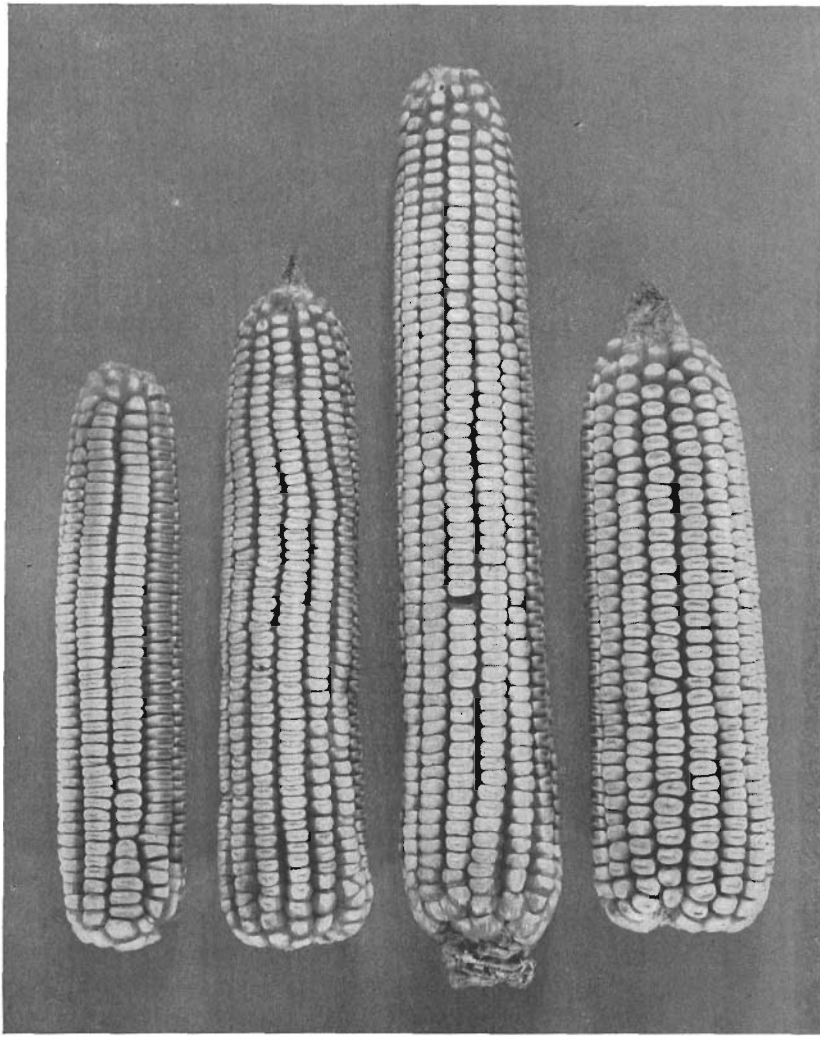
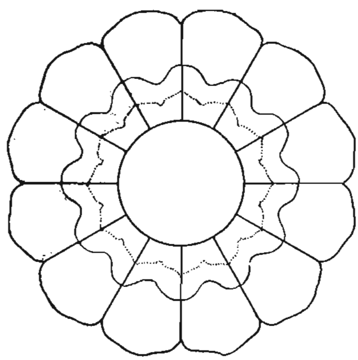


FIG. 88. Tuxpeño. These attractive cylindrical dent ears are from the race Tuxpeño which is the predominant commercial type along the Gulf Coast Plain from Southern Mexico to the southern states of the U.S.A. Most of the modern productive agricultural types of Mexico contain varying amounts of germplasm from this race. Scale 1 cm. = 2.46 cm.

Olotillo types found in Guerrero superficially appear to be similar to the sub-race Dzit-Bacal in Yucatán (Fig. 83, ear on right). Others are more similar to the Chiapas type. It is difficult to say whether most of the Olotillo types that exist in Guerrero originally came from the common type in Chiapas or from Dzit-Bacal in Yucatán. Perhaps both types were introduced and the present situation is a mixture of both types combined with considerable reciprocal introgression of Pepitilla into Olotillo and Olotillo into Pepitilla. Many of the eight-rowed Olotillo types in Guerrero have



TUXPEÑO

FIG. 89.

a dirty white endosperm which they could have gotten from Pepitilla. Also in many of them the beaked kernel so prominent in Pepitilla is clearly evident.

TUXPEÑO

Plants. Tall, 3–4 meters in its native habitat; very late; few tillers; many leaves that are broad especially in relation to length; venation index medium high; sun-red or purple color slight; pubescence very slight; moderately susceptible to rust; average number of knobs 6.1. Adapted to low elevations.

Tassels. Long, many branches with approximately 20 percent of total being secondary branches; tertiary branching infrequent; condensation index medium.

Ears, External Characters. (Fig. 88) Medium long to long, medium slender, cylindrical; number of rows 12–14; thick shank;

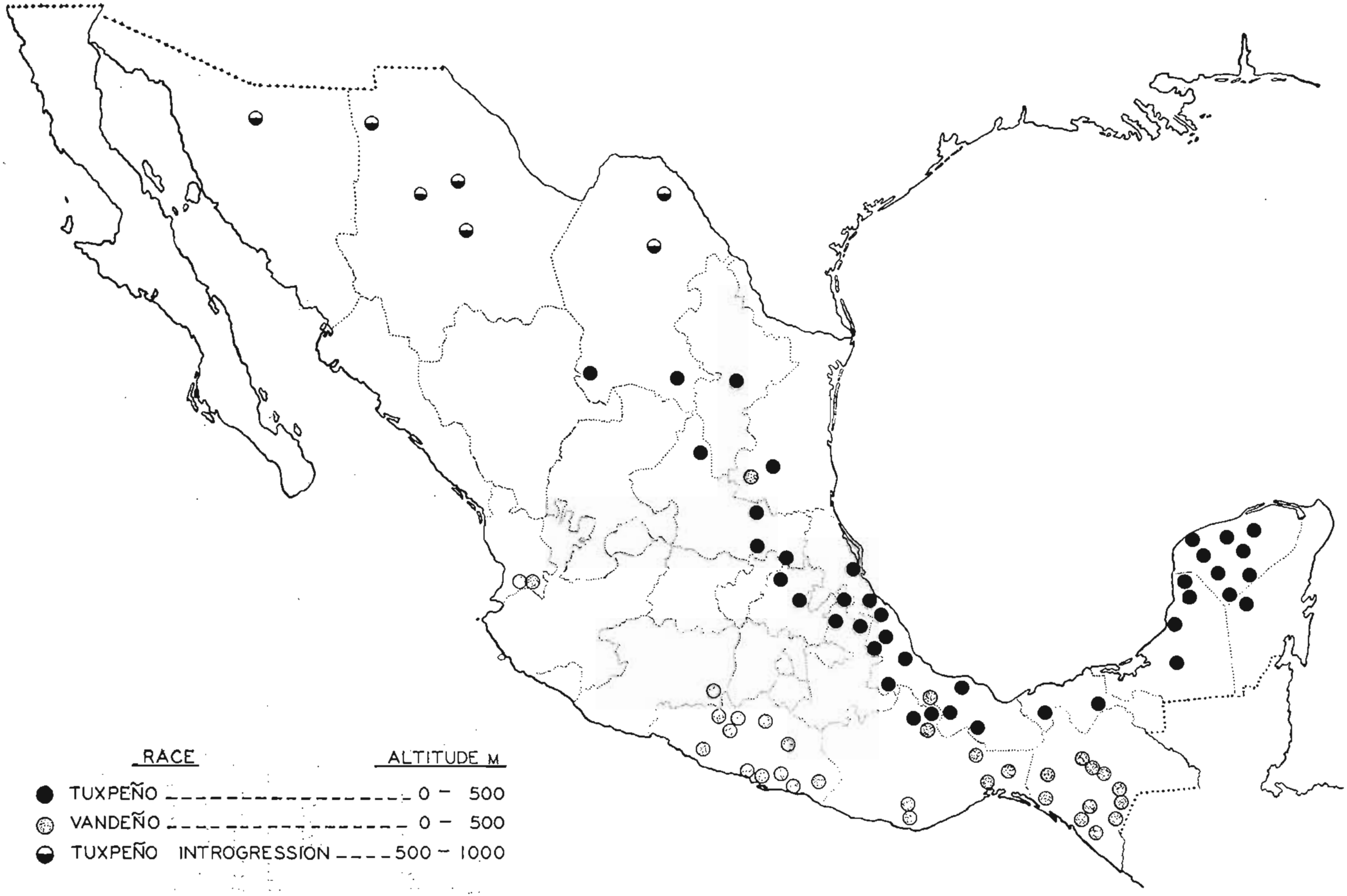


FIG. 90. Distribution of Tuxpeño, Vandeño and types resulting from the introgression of Tuxpeño.

mid-cob color in 58% of the ears examined. Kernels wide, medium thick, medium long, deep denting; slight striations; endosperm medium hard, white; aleurone and pericarp generally colorless.

Ears, Internal Characters. (Fig. 89) Ear diameter 44–48 mm.; cob diameter 25–28 mm.; rachis diameter 16–17 mm.; kernel length 12.8 mm.; estimated rachilla length 2.2 mm.; cob/rachis index low, 1.61; glume/kernel index low, 0.39; rachilla/kernel index medium, 0.17; pedicel hairs variable, none to many long; cupule hairs few, variable in length; rachis flap weak; lower glumes horny, few short surface hairs, many marginal hairs of intermediate length, the margins deeply cordate; upper glumes fleshy, stiff, glabrous or sparsely hairy, the margins with no hairs or few; tunicate allele tu^{w}; rachis tissue horny to bony; teosinte introgression strong.

Distribution. Tuxpeño is extensively grown and is by far the most important race along the Gulf coast from sea level to 500 meters elevation. Its distribution along the coastal areas from Yucatán to northeastern Mexico is shown by the solid black circles in Fig. 90. Practically all the corn of the Gulf coast today is produced from varieties of this race. Many of the varieties in northern Sonora, Chihuahua and Coahuila at elevations of 500 to 1,000 meters (black and white circles, Fig. 90) show a strong introgression of Tuxpeño. They are cylindrical in shape but many-rowed and thick-cobbed, characteristics which are more highly accentuated in the west coast counterpart of Tuxpeño to be described later as Vandeño.

Origin and Relationships. Tuxpeño is intermediate between Olotillo and Tepecintle in a large number of important characteristics including height of plant, number of leaves, venation index, diameter of ear, diameter of cob and rachis, maturity, rust resistance, frequency of mid-cob color, and average number of chromosome knobs (Table 7). In many of its other characteristics it approaches very closely either one or the other of its putative parents. Some of the ear relationships between Tuxpeño and its probable progenitors, Olotillo and Tepecintle, are easily discernible in Fig. 91 and in the diagrammatic cross sections (Fig. 92). In internode patterns (Plate VII) the three races are quite similar.

TABLE 7. Comparison of Tuxpeño With Its Probable Progenitors, Olotillo and Tepecintle.

	Olotillo	*Tuxpeño*	*Tepecintle*
Plant Characters			
Height (meters)	2.9	2.7	1.8
No. of Leaves	20.0	18.0	13.6
Width of Leaves (cm.)	10.5	10.5	10.0
Length of Leaves (cm.)	—	95.0	85.7
Venation Index	3.23	3.11	2.88
Tassel Characters			
Length (cm.)	39.2	42.6	41.5
Length of Branching Space (cm.)	17.6	14.4	14.4
Percent of Branching Space	45.0	30.0	34.0
No. of Branches	30.3	22.9	24.7
Percent Secondary Branches	34.0	20.5	21.5
Condensation Index	1.01	1.55	1.08
External Characters of Ear			
Length (cm.)	19.8	19.7	10.4
Diameter (cm.)	3.8	4.4	4.9
Row Number	9.4	12.6	11.8
Shank Diameter (mm.)	10.5	13.4	10.8
Width of Kernel (mm.)	10.8	9.3	9.1
Thickness of Kernel (mm.)	3.9	3.7	3.7
Length of Kernel (mm.)	11.7	12.8	11.9
Internal Characters of Ear			
Diameter of Cob (mm.)	22.7	26.5	32.8
Diameter of Rachis (mm.)	9.7	16.5	20.5
Length of Rachilla (mm.)	2.3	2.2	3.3
Cob/rachis Index	2.34	1.61	1.60
Glume/kernel Index	0.56	0.39	0.52
Rachilla/kernel Index	0.20	0.17	0.28
Pedicel Hairs	0–3	0–4	0
Rachis Flap	1	1	1–3
Rachis Induration	1+	1+	1–2
Teosinte Introgression	3	3	4
Physiological, Genetic and Cytological Characters			
No. Days to Anthesis	135	148	113
Rust Resistance	2–3	3	4
Pilosity	1	1	1
Sheath Color	1	1–2	2
Mid-cob Color, Percent	0	58	42
Chromosome Knobs, Range	5–9	6–7	6–11
Average No.	6.3	6.1	9.0

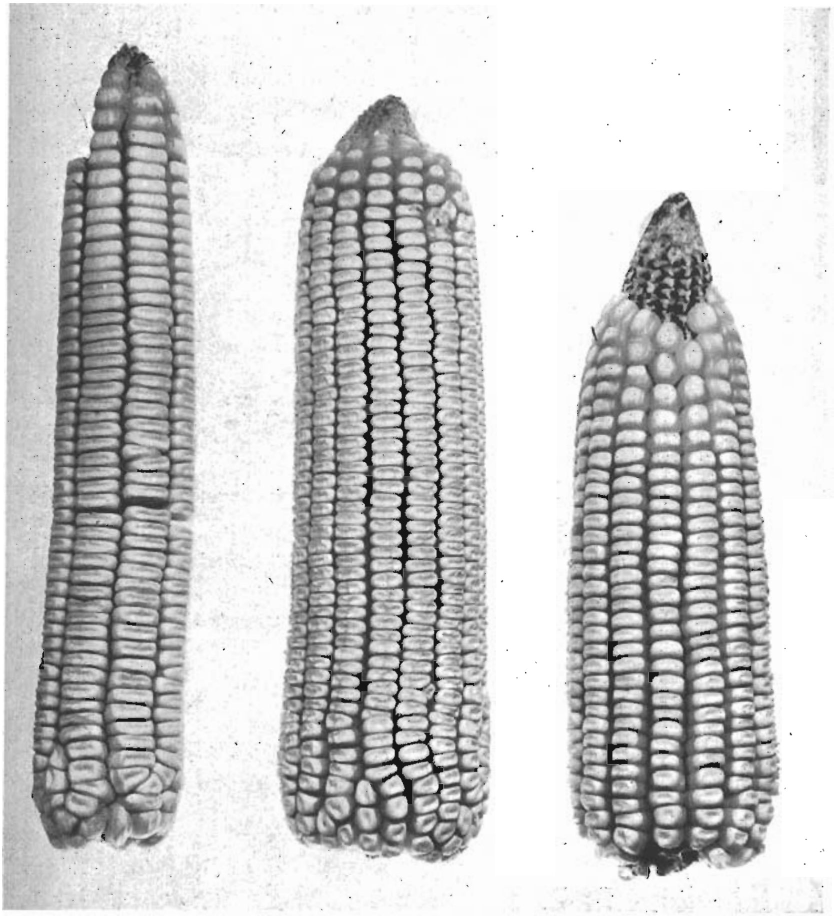


FIG. 91. Origin of Tuxpeño. Tuxpeño (center) is intermediate in most of its characters between Olotillo (left) and Tepecentle (right) which is strong evidence for its hybrid origin from these two races. Scale 1 cm. = 1.93 cm.

There seems little reason to doubt that Tuxpeño is basically the product of the hybridization of Olotillo and Tepecintle which have overlapping distributions (Figs. 57 and 85). The proposed genealogy of Tuxpeño is given in Fig. 93.

From the standpoint of its influence upon modern productive agricultural races of both Mexico and the United States, Tuxpeño is one of the most important of all maize races. It has been involved in the ancestry of some of the most productive and desirable agronomic races in Mexico such as Celaya, Chalqueño and Cónico Norteño, which will be described later as Modern Races. Also, as pointed out under the discussion of the distribution of Tuxpeño, many of the varieties in northern Mexico in the states of Sonora,

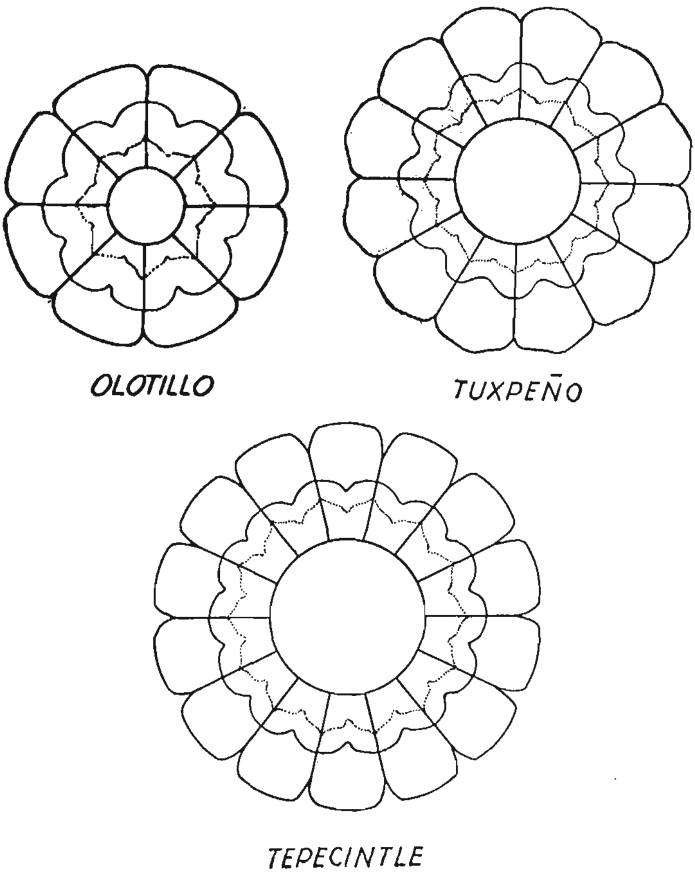


FIG. 92. A comparison of the diagrammatic ear cross sections of Olotillo, Tuxpeño and Tepecintle.

Chihuahua and Coahuila show affinities with Tuxpeño. Furthermore, Tuxpeño has been the source of germplasm of the Southern Dents of the United States. Archaeological remains of cylindrical shaped ears bearing kernels with pronounced denting have been found in Arkansas by Gilmore (1931). To have had such a broad influence on so many different modern races Tuxpeño must have been of pre-Columbian origin although perhaps relatively recent in comparison to most of the races whose descriptions have gone before.

Derivation of Name. From the name of the town, Tuxpan, Veracruz, which is located on the Gulf Coastal Plain near the city

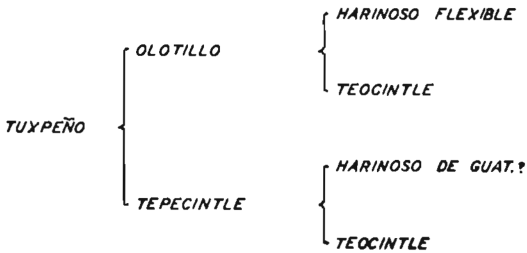


FIG. 93. The probable origin of Tuxpeño.

of Veracruz. The Spanish ending "eño" means "coming from". This name was chosen because the town of Tuxpan is the approximate center of distribution of the race.

References. Chávez, 1913; Pérez Toro, 1942 (as Xnuc-Nal); Brown and Anderson, 1948.

VANDEÑO

Plants. Medium height, approximately 2.5 to 3 meters; medium maturity; few tillers; medium number of leaves with medium venation index; medium amount of color with considerable purple; slight pubescence; highly susceptible to rust; average number of knobs 8.1. Adapted to low elevations, 0–500 meters.

Tassels. Long, many branches; secondaries numerous, tertiaries infrequent; condensation index low.

Ears, External Characters. (Fig. 94) Medium short, medium broad, cylindrical with very slight taper towards tip; average row number 13.2; medium large shank; mid-cob color in 29% of ears examined. Kernels medium size, strong denting; striations slight; endosperm medium hard, white; aleurone and pericarp colorless.

Ears, Internal Characters. (Fig. 95) Ear diameter 51–55 mm.; cob diameter 32–33 mm.; rachis diameter 17–21 mm.; kernel length 13.9 mm.; estimated rachilla length 3.1 mm.; cob/rachis index low, 1.70; glume/kernel index low, 0.48; rachilla/kernel index medium, 0.22; pedicel hairs none to few long; cupule hairs intermediate to many, intermediate to long; rachis flap weak; lower glumes horny, few surface hairs, few to many marginal hairs, the

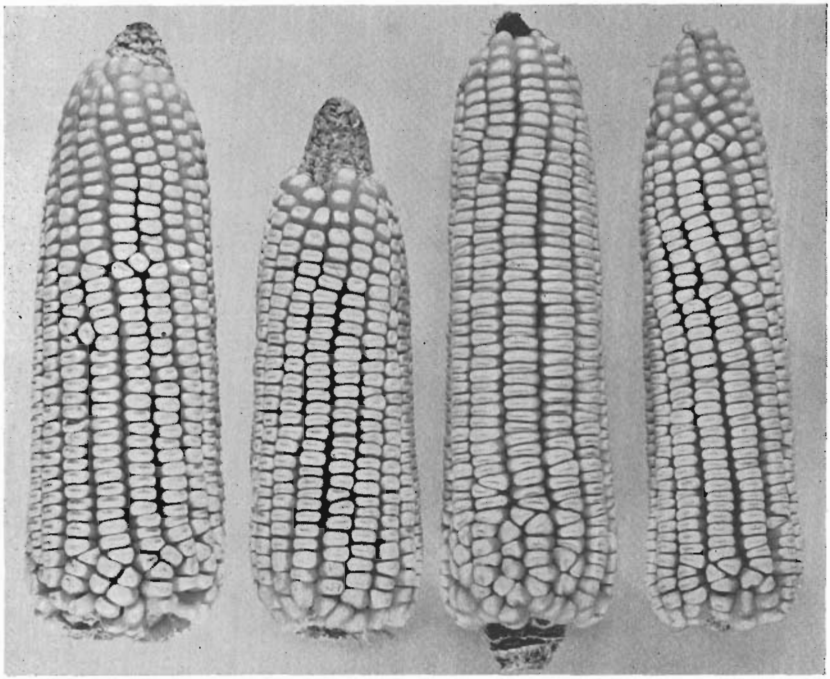
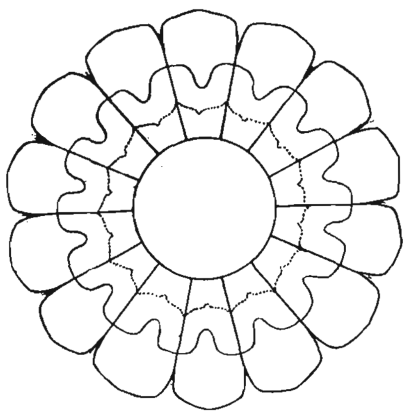


FIG. 94. Vandeño. Along the Pacific Coastal Plain from Chiapas to Michoacán, the cylindrical dent race, Vandeño, predominates. This race is not greatly different from Tuxpeño of the Gulf Coastal Plain. The plants are shorter and earlier in maturity and the ears are shorter with a slightly larger diameter. These differences are probably due to the introgression of Zapalote Grande or Tehua into Tuxpeño. Scale 1 cm. = 2.49 cm.

margins cordate; upper glumes fleshy, stiff, few to many short basal surface hairs, few marginal hairs; tunicate allele tu^w; rachis tissue horny; teosinte introgression strong.

Distribution. The locations where Vandeño has been collected are shown by the stipled circles in Fig. 90. It is the most common race along the Pacific coast from Chiapas to Michoacán at elevations of 0–500 meters. It has been found as far north as Nayarit and Baja California which appears to be the northern extremity of its range, for it is considered inferior to Tabloncillo in these areas because of its later maturity. No attempt has as yet been made to collect the corns of the coastal areas in the states of Jalisco and Michoacán. However, since collections of Vandeño have been made both to the north and south of this section of the west coast, it is reasonable to assume that this race has a continuous range of distribution along the Pacific Coastal Plain extending from at least the Guatemalan border in Chiapas to as



VANDEÑO

FIG. 95.

far north as the state of Nayarit. Evidence indicates that Vandeño is better adapted to the southern part of its range and that as the northern limit of its range is approached the race is to be found less frequently.

Vandeño may also occasionally be found in the Gulf Coastal Plains area along with Tuxpeño, especially near the Isthmus of Tehuantepec. Furthermore, the cylindrical dents in northern Mexico since they are generally earlier and thicker cobbed than Tuxpeño may be basically Vandeño.

Origin and Relationships. Vandeño shows many striking similarities to Tuxpeño, its Gulf coast counterpart. The resemblance in ear characteristics can be observed in Figs. 88 and 94, and in the diagrammatic cross sections, Plate V. Both races produce attractive cylindrical shaped ears with the kernels showing pronounced denting. The ears of Vandeño, however, are somewhat shorter

TABLE 8. Comparison of Vandeño With Its Probable Progenitors, Zapalote Grande and Tuxpeño.

	Zapalote Grande	*Vandeño*	*Tuxpeño*
Plant Characters			
Height (meters)	1.6	2.5	2.7
No. of Leaves	15.9	13.7	18.0
Width of Leaves (cm.)	9.6	9.5	10.5
Length of Leaves (cm.)	81.4	93.3	95.0
Venation Index	2.92	3.00	3.11
Tassel Characters			
Length (cm.)	39.7	40.5	42.6
Length of Branching Space (cm.)	13.0	12.5	14.4
Percent of Branching Space	30.0	33.0	30.0
No. of Branches	23.9	20.8	22.9
Percent Secondary Branches	12.6	18.2	20.5
Condensation Index	1.55	1.21	1.55
External Characters of Ear			
Length (cm.)	14.8	17.2	19.7
Diameter (cm.)	4.9	5.1	4.4
Row Number	15.7	13.2	12.6
Shank Diameter (mm.)	18.1	13.0	13.4
Width of Kernel (mm.)	9.3	9.1	9.3
Thickness of Kernel (mm.)	3.8	3.6	3.7
Length of Kernel (mm.)	11.1	13.9	12.8
Internal Characters of Ear			
Diameter of Cob (mm.)	31.5	32.3	26.5
Diameter of Rachis (mm.)	19.2	19.0	16.5
Length of Rachilla (mm.)	2.7	3.1	2.2
Cob/rachis Index	1.64	1.70	1.61
Glume/kernel Index	0.55	0.48	0.39
Rachilla/kernel Index	0.24	0.22	0.17
Pedicel Hairs	1–2	0–3	0–4
Rachis Flap	1	1	1
Rachis Induration	1–2	1+	1+
Teosinte Introgression	2–3	3	3
Physiological, Genetic and Cytological Characters			
No. Days to Anthesis	118	125	148
Rust Resistance	3–4	3–4	3
Pilosity	1	1	1
Sheath Color	1–2	2–3	1–2
Mid-cob Color, Percent	0	29	58
Chromosome Knobs, Range	6–9	6–11	6–7
Average No.	7.4	8.1	6.1

in length and generally have a thicker cob and a higher row number. Measurements on most of the plant and tassel characters give a lower figure than the same measurements for Tuxpeño, as evident in Table 8. It appears that both Vandeño and Tuxpeño

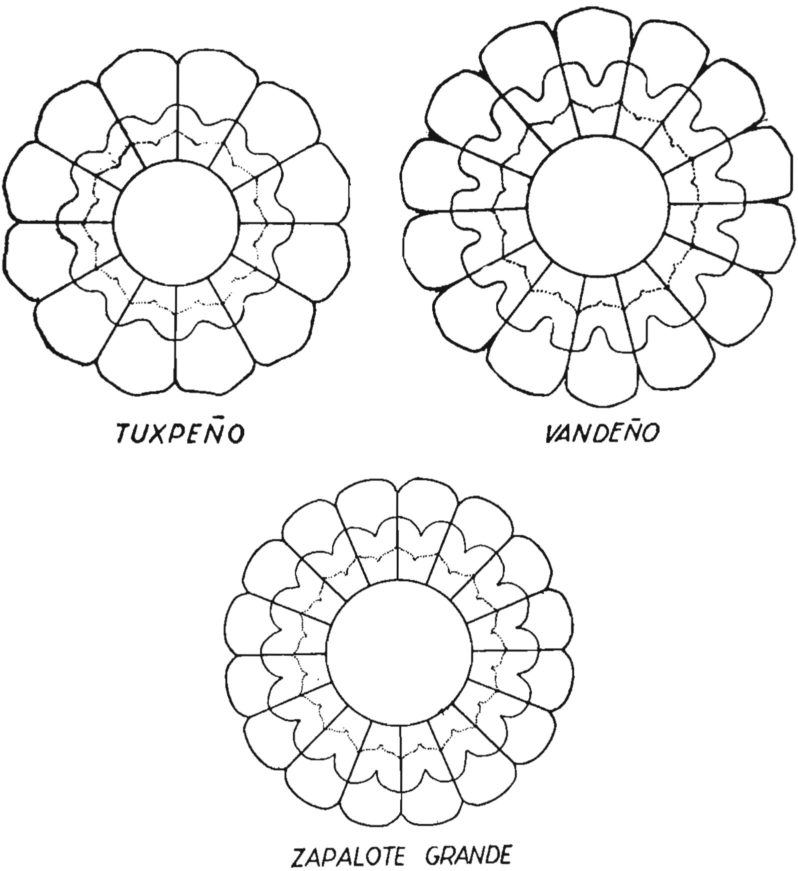


FIG. 96. A comparison of the diagrammatic ear cross sections of Tuxpeño, Vandeño and Zapalote Grande.

trace back to a common origin resulting principally from the hybridization between Olotillo and Tepecintle. However, Tuxpeño, the predominating type on the Gulf coast, tends to have a higher proportion of Olotillo, whereas Vandeño, the predominating type on the west coast, seems to have a higher proportion of Tepecintle and in addition shows a strong introgression of the Zapalote complex. Vandeño overlaps Tepecintle, Zapalote Grande and Zapalote Chico in its distribution (Figs. 54, 57 and 90). It is intermediate between Tuxpeño and Zapalote Grande in many of the external and internal characters of the ears, as shown in Table 8 and by the diagrammatic cross sections (Fig. 96). It is also intermediate between Tuxpeño and Zapalote Grande in height, maturity, length of leaves, venation index, length of tassel, rust resistance and mid-cob color. In addition it resembles Zapalote Grande or exhibits characters of Zapalote Grande in exaggerated form in several other respects. Zapalote Grande, as evident in Tables 13 to 17, is similar in many of its characters to Tepecintle, and Vandeño is also similar to Tepecintle as well as Tuxpeño in many of its characters. We suspect that Zapalote Grande differs from Tepecintle primarily in that its teosinte germplasm has been diluted by Nal-Tel. The striking similarities in internode pattern among Tuxpeño, Vandeño, Olotillo, Tepecintle, Zapalote Grande and Zapalote Chico may be seen in Plate VII. All evidence indicates that Vandeño differs from Tuxpeño primarily through a stronger introgression of the Zapalote complex. Its genealogy is given in Fig. 97.

Evidence strongly supporting the postulated origins of both Tuxpeño and Vandeño comes from inbreeding. Several varieties of these tropical cylindrical dents from Veracruz and Tamaulipas have been inbred from one to five generations. Some of the later more slender-eared varieties upon inbreeding have segregated principally ear types approaching Olotillo, Tepecintle and a thick-cobbed, high-rowed flour corn. Some of the earlier varieties from Tamaulipas and northern Veracruz have segregated ear types approaching Zapalote Grande, Zapalote Chico and Nal-Tel in addition to Olotillo and the thick-cobbed, high-rowed flour types (Fig. 98). This bears out the statement made earlier that many of the northern cylindrical dents may be basically Vandeño.

There is no doubt that Olotillo has been basic in the formation of the various varieties of cylindrical dent which have become divided into two more or less distinct races by differences in amount of introgression into Olotillo of the Tepecintle and Zapalote complexes. The race, Vandeño, somewhat earlier in maturity and showing the higher proportion of Zapalote and

Tepecintle, has become better adapted to the drier areas of the Pacific Coastal Plains, whereas Tuxpeño, later in maturity and more Olotillo-like in its composition, has become better adapted to the areas with higher rainfall on the Gulf coast. Both have been found in the same area. The fact that some of the varieties in northern Mexico are quite similar to Vandeño, the predominating type of corn in the southern Pacific Coastal Plain area, is not surprising since both areas are relatively low in elevation and have a short irregular rainy season.

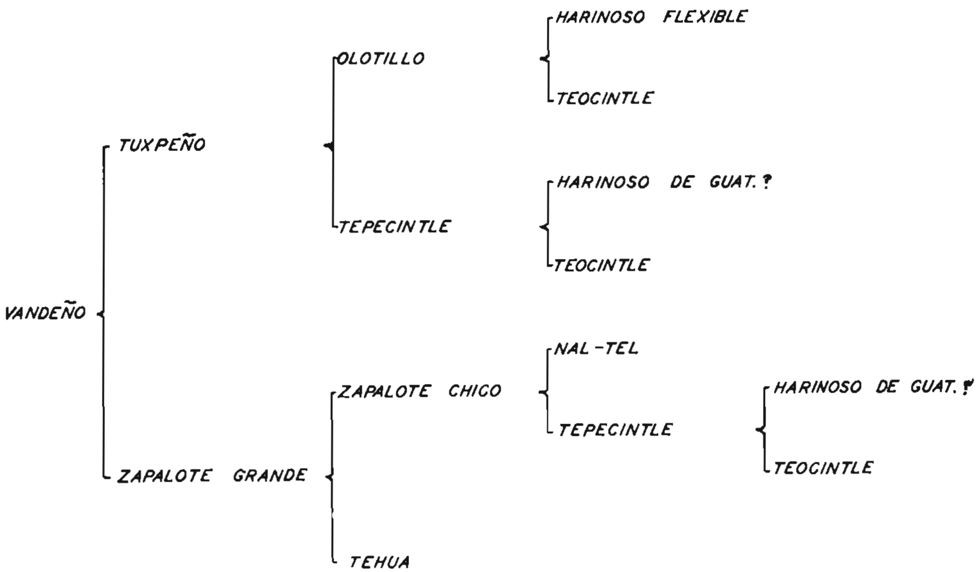


FIG. 97. The probable origin of Vandeño.

Derivation of Name. Common local name in its region of adaptation. Meaning unknown.

References. Chávez, 1913.

MODERN INCIPIENT RACES

Modern Incipient races, those which comprise the fourth and last group of well-defined races, are races which have developed since the Conquest and which have not yet reached a state of racial stability. In some cases the origin of these races is quite recent indeed. The race Celaya, for example, the most important agricultural race in the Bajio, Mexico's counterpart of the Corn

Belt, has come into prominence within the memories of the oldest inhabitants of the region. It is still quite variable in many respects, but already possesses a group of characteristics which make it recognizable as a race. Furthermore, it is already widely grown

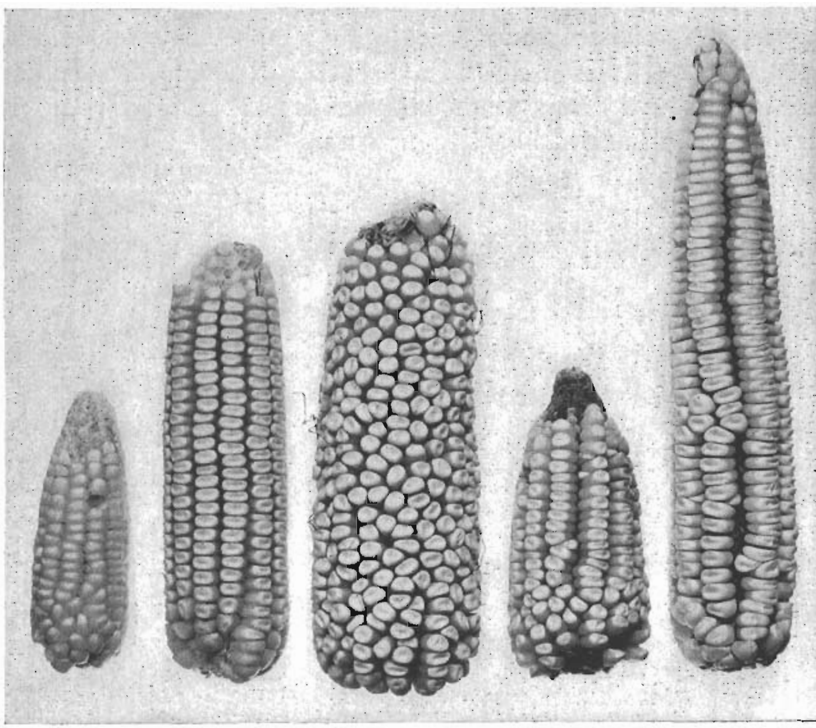


FIG. 98. A range of different types of ears obtained upon inbreeding Vandeño and Tuxpeño. Note the similarities in ear type (from left to right) to (1) Nal-Tel, (2) Tuxpeño, (3) big-cobbed Guatemalan flour, (4) Zapalote Chico, and (5) Olotillo. Scale 1 cm. = 2.38 cm.

and is becoming increasingly important agriculturally. All of these characteristics distinguish it, as well as the other races included in the Modern Incipient group, from more recent mixtures which are common in all parts of Mexico but which have not yet reached a state of sufficient stability to be recognizable as races.

CHALQUEÑO

Plants. Medium to very tall, from 2 to 5 meters; usually medium maturity, 5 to 6 months; few to medium number of tillers; medium number of leaves which are fairly wide and medium long; venation index medium, 2.93; medium color; medium pubescence; highly resistant to rust; average number of knobs 6.8. Adapted to high elevations, 1,800–2,300 meters.

Tassels. Long, few branches with percentage of secondaries low, tertiaries absent; condensation index high, 2.55.

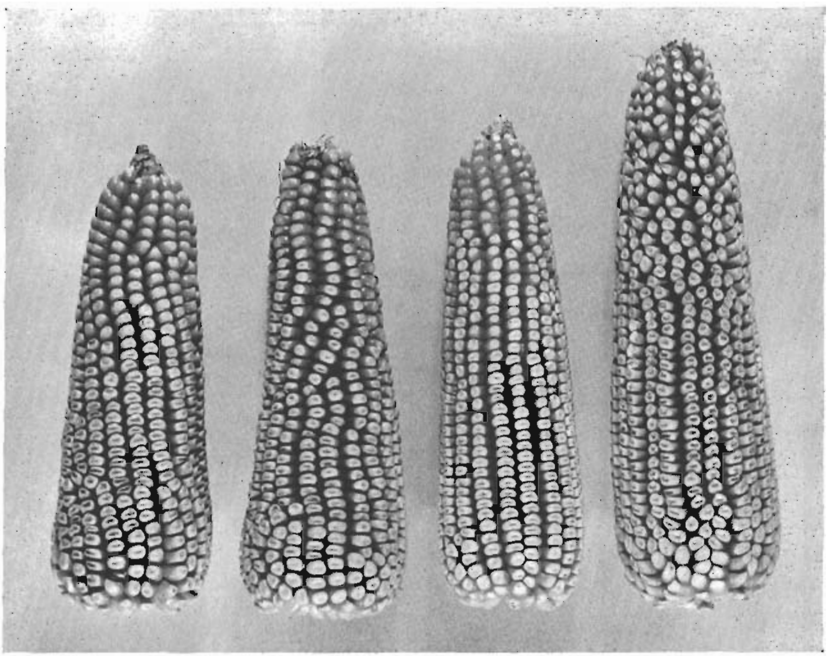


FIG. 99. Chalqueño. This race is a relatively recent one and is one of the most vigorous and productive agricultural types for early planting in the Central High Plateau. Scale 1 cm. = 3.13 cm.

Ears, External Characters. (Fig. 99) Medium long, broad; average row number 16.6; medium strong uniform taper from base to tip; shank diameter medium; mid-cob color in 30% of ears examined; kernels medium narrow, medium thin, and long, tendency to pointing with medium to well-developed dent; striations absent; endosperm medium soft; dirty white; aleurone and pericarp colorless.

Ears, Internal Characters. (Fig. 100) Ear diameter 49–52 mm.; cob diameter 26–30 mm.; rachis diameter 15 mm.; kernel length 15–16 mm.; estimated rachilla length 2.7 mm.; cob/rachis index medium, 1.89; glume/kernel index low, 0.43; rachilla/kernel index low, 0.18; pedicel hairs many and long; cupule hairs many, intermediate to long; rachis flap intermediate; lower glumes fleshy, some with transparent margins, few long surface hairs, the margins cordate; upper glumes chaffy with transparent margins, wrinkled, many long surface hairs, few or no marginal hairs; tunicate alleles *tu* and tu^{w}; rachis tissue horny; teosinte introgression intermediate.

Distribution. Chalqueño has a geographical distribution almost

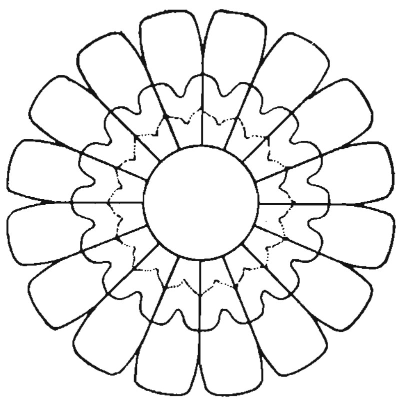


Fig. 100.

spatially identical to that of Cónico in the Mesa Central as shown in Figs. 101 and 32, but because of its late maturity it differs from Cónico in its range of adaptation to altitude. The lower and upper limits of altitude adaptation for Chalqueño are approximately 1800 meters and 2300 meters respectively, whereas Cónico most generally ranges from 2200 to 2800 meters. Although both races are often found in the same general area and at the same altitude they do not compete for the same land. There are two rather distinct and well defined conditions in the Mesa Central with respect to the use of land for corn. Land that has irrigation facilities or reserve sub-surface soil moisture sufficient to germinate deep-planted seeds is usually planted to the late maturing more vigorous and productive type Chalqueño as soon as the danger of frost is past, which varies according to elevation but at 2200

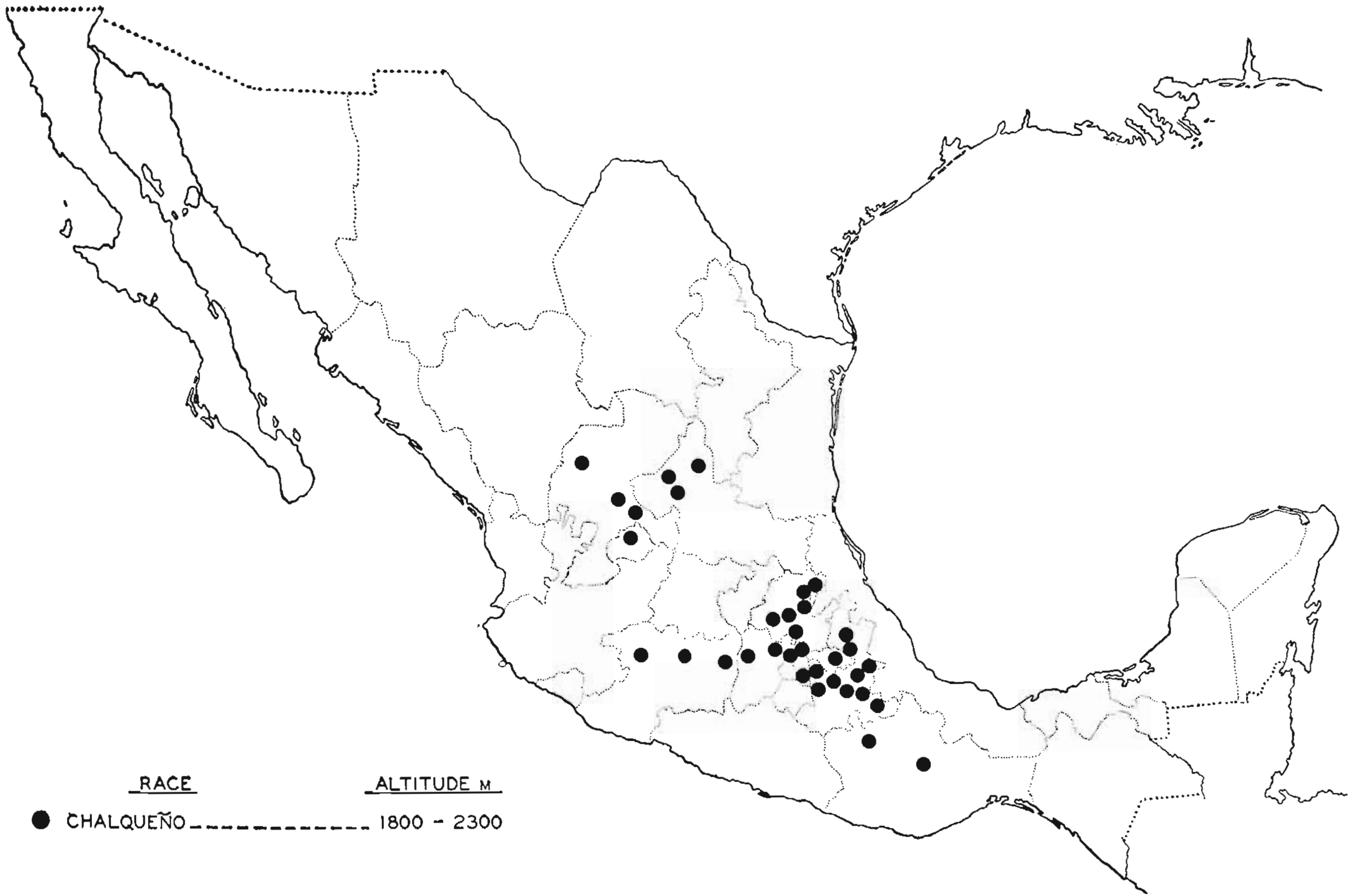


FIG. 101. Distribution of Chalqueño.

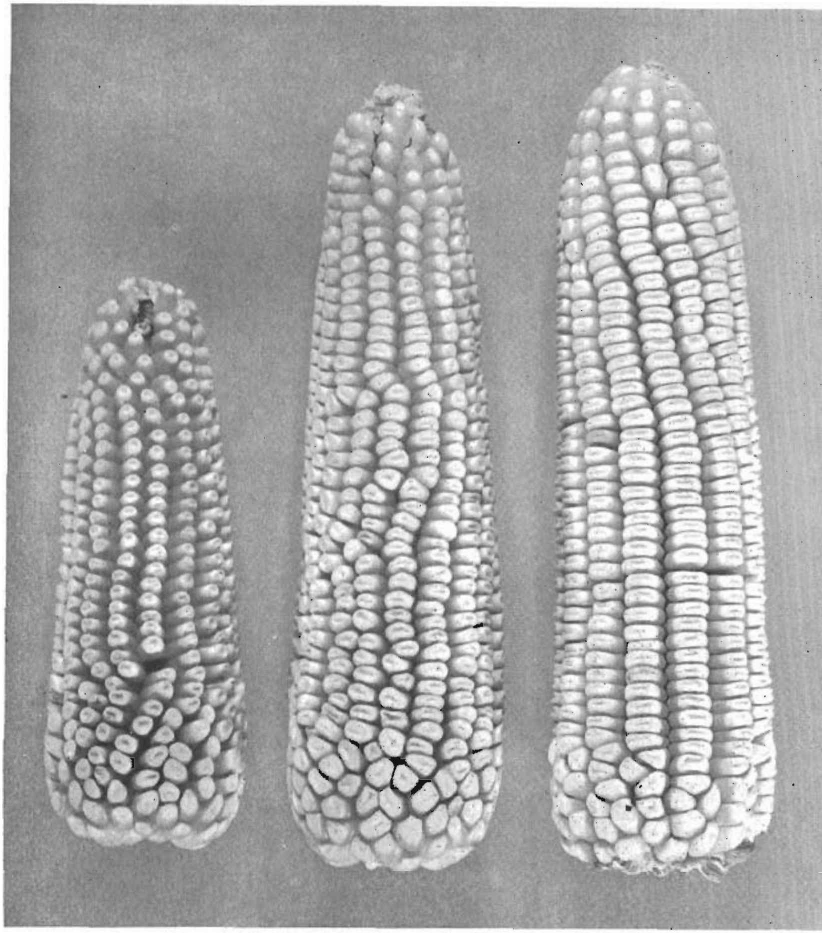


FIG. 102. Origin of Chalqueño. Chalqueño (center) probably resulted from natural hybridization between Cónico (left) and Tuxpeño (right). Scale 1 cm. = 1.96 cm.

meters is usually in late March or early April. Land without irrigation facilities or sufficient moisture reserve cannot be planted until the rainy season begins usually about the first of June; and since the first killing frost in the Mesa Central can be expected in the first days of October an earlier corn is required. For such conditions Cónico is best adapted and almost exclusively used.

The varieties of Chalqueño vary considerably in their vigor and length of time required for maturity. At Nochixtlan in Oaxaca a variety called Cajete is planted in February and matures in

November. In fertile soil this variety often reaches 5 meters in height. At the lower range of its altitude adaptation varieties of this race are generally taller and later in maturity. Although Chalqueño is primarily limited to the Mesa Central, Anderson (1947b) reported a type of corn similar to Chalqueño from the

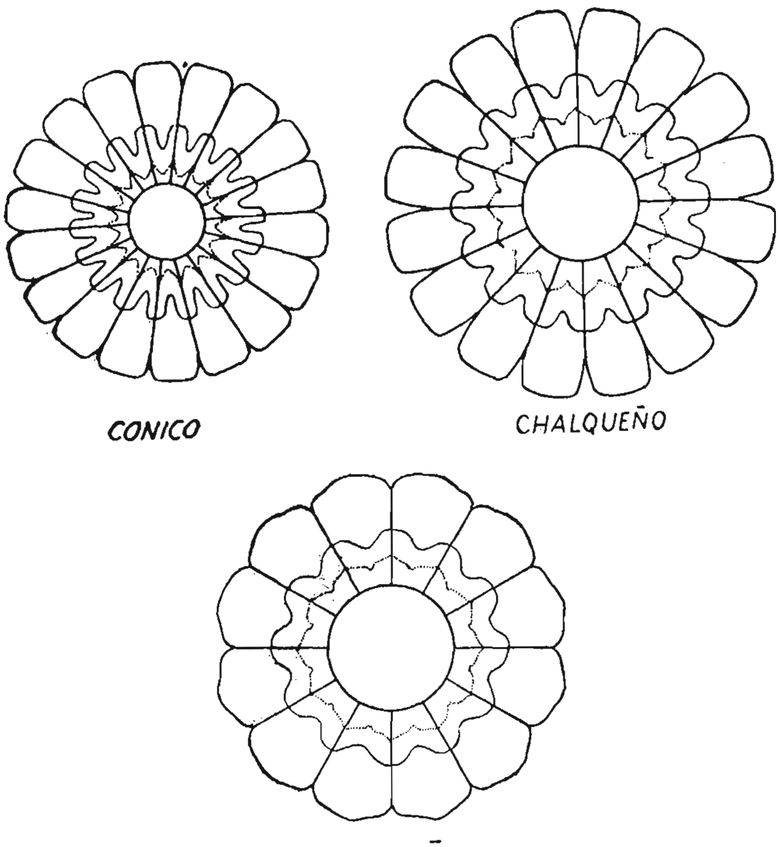


FIG. 103. A comparison of the diagrammatic ear cross sections of typical ears of Cónico, Chalqueño and Tuxpeño.

highlands of Guatemala, and we have found a few varieties very similar to Chalqueño in the highlands of Chiapas.

Origin and Relationships. Chalqueño is almost certainly the product of the hybridization of Cónico and Tuxpeño. This race possesses very few characteristics which are not like those of one

TABLE 9. Comparison of Chalqueño With Its Probable Progenitors, Cónico and Tuxpeño.

	Cónico	*Chalqueño*	*Tuxpeño*
Plant Characters			
Height (meters)	1.7	2.3	2.7
No. of Leaves	11.2	14.7	18.0
Width of Leaves (cm.)	8.2	9.7	10.5
Length of Leaves (cm.)	72.0	84.1	95.0
Venation Index	2.78	2.93	3.11
Tassel Characters			
Length (cm.)	34.5	43.0	42.6
Length of Branching Space (cm.)	4.5	7.9	14.4
Percent of Branching Space	14.0	19.0	30.0
No. of Branches	5.5	10.7	22.9
Percent Secondary Branches	7.0	10.1	20.5
Condensation Index	2.58	2.55	1.55
External Characters of Ear			
Length (cm.)	13.6	16.0	19.7
Diameter (cm.)	4.3	4.9	4.4
Row Number	16.0	16.6	12.6
Shank Diameter (mm.)	8.8	10.1	13.4
Width of Kernel (mm.)	6.6	7.2	9.3
Thickness of Kernel (mm.)	3.6	3.9	3.7
Length of Kernel (mm.)	14.8	15.4	12.8
Internal Characters of Ear			
Diameter of Cob (mm.)	19.0	28.3	26.5
Diameter of Rachis (mm.)	9.6	15.0	16.5
Length of Rachilla (mm.)	1.6	2.7	2.2
Cob/rachis Index	1.98	1.89	1.61
Glume/kernel Index	0.32	0.43	0.39
Rachilla/kernel Index	0.11	0.18	0.17
Pedicel Hairs	2–4	4	0–4
Rachis Flap	2–3	2	1
Rachis Induration	0	1	1+
Teosinte Introgression	0	2	3
Physiological, Genetic and Cytological Characters			
No. Days to Anthesis	90	107	148
Rust Resistance	1	1	3
Pilosity	3–4	2–3	1
Sheath Color	4–5	2–3	1–2
Mid-cob Color, Percent	39	30	58
Chromosome Knobs, Range	—	6–7	6–7
Average No.	1.0	6.8	6.1

or the other of the probable progenitors or intermediate between them, as an examination of the data presented in Table 9 will reveal. The principal exceptions to this intermediate condition are in characteristics in which hybrid vigor is probably a factor, such as ear and cob diameter and kernel length. Chalqueño

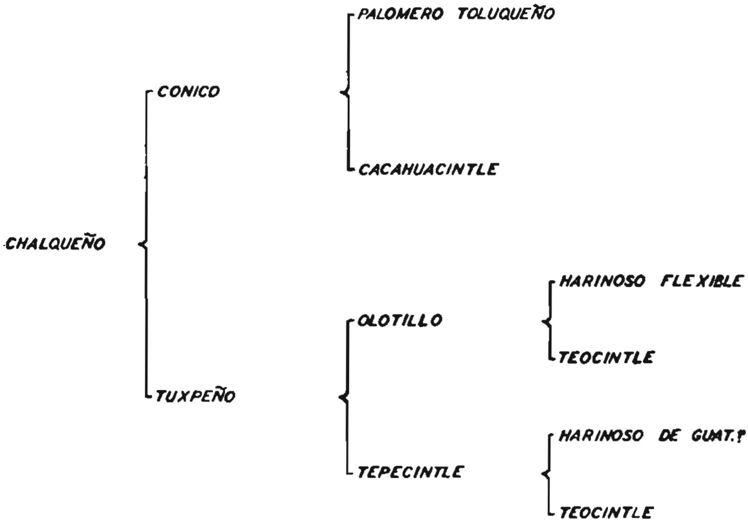


FIG. 104. The probable origin of Chalqueño.

resembles Cónico in its internode pattern (Plate VII) and in its high row number, length of kernel and resistance to rust. It is like Tuxpeño in its cob and rachis diameter, chromosome knob number and resembles some varieties of Tuxpeño in possessing long glumes, long rachillae and prominent pedicel hairs. Relationship in ear characters is clearly evident in Figs. 102 and 103. The probable origin of Chalqueño is illustrated in Fig. 104.

When Chalqueño is inbred it "breaks up" into types with a Cónico-like form as one extreme and a Tuxpeño-like form as the other. The former has the early-maturing short plants, few tassel branches, leaf sheaths with strong pubescence and sun-red color, resistance to rust, and weak root system characteristic of Cónico; while the latter has the contrasting characteristics typical of Tuxpeño.

Chalqueño apparently is of rather recent origin. Its spread into

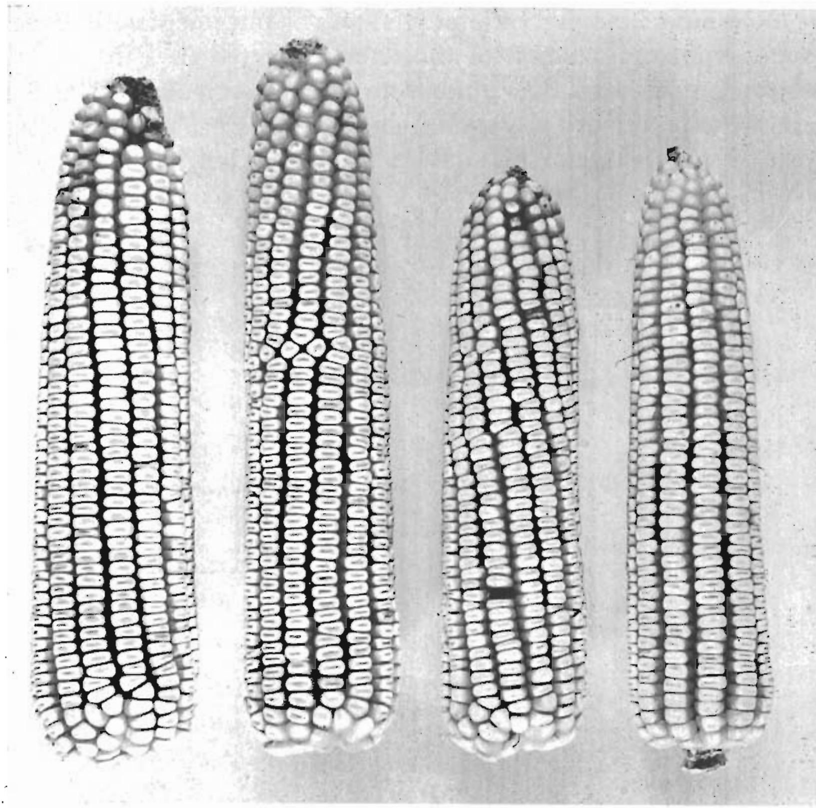


FIG. 105. Celaya. Celaya is the most productive agricultural race that has been found in the Central Bajío and is one of the most productive and useful races in Mexico. Scale 1 cm. = 2.48 cm.

the Chalco area of the valley of Mexico is an event which has occurred within the memory of the older inhabitants. There is also some indication that the germplasm which has gone into the formation of Chalqueño has not become as completely integrated as many of the other races, which is further evidence of the recent origin of this race. It has not, as far as we have been able to determine, entered into the origins of any other races in Mexico.

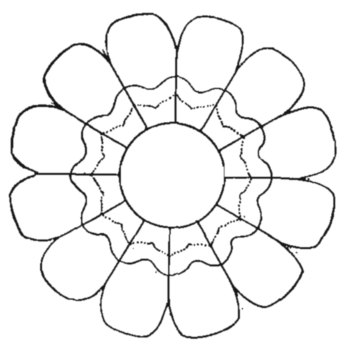
The very tall, very late varieties of Chalqueño, such as Cajete, grown at the lower limits of the range of this race in adaptation to altitude show less of the Cónico complex and resemble Tuxpeño more closely. In contrast, those grown at the higher altitudes show a higher introgression of Cónico.

Derivation of Name. Taken from the name of Chalco, a village in the valley of Mexico located approximately 35 kilometers to the southeast of Mexico City. It is in this region that the race has gained its greatest popularity and is most extensively grown.

References. López y Parra, 1908b; Chávez, 1913; Montelongo, 1939; Wellhausen, 1947; Bautista R., 1949.

CELAYA

Plants. Medium tall, about 2 to 3 meters; medium late; few tillers; numerous leaves; venation index low; color very slight to absent; pubescence very slight; medium resistant to rust; number of knobs 8–10. Adapted to medium elevations, 1,200–1,800 meters.



CELAYA

FIG. 106.

Tassels. Long; medium high number of branches with some secondary and few tertiary branches; low condensation index.

Ears, External Characters. (Fig. 105) Medium length, medium slender, cylindrical; average row number 12.4; shank diameter medium; mid-cob color in 67% of ears examined. Kernels medium wide, medium thin, medium long, strongly dented; striations slight; endosperm medium hard, white; aleurone and pericarp colorless.

Ears, Internal Characters. (Fig. 106) Ear diameter 43–47 mm.; cob diameter 20–27 mm.; rachis diameter 12–15 mm.; kernel length 12–14 mm.; estimated rachilla length 2.4 mm.; cob/rachis index low, 1.70; glume/kernel index low, 0.37; rachilla/kernel

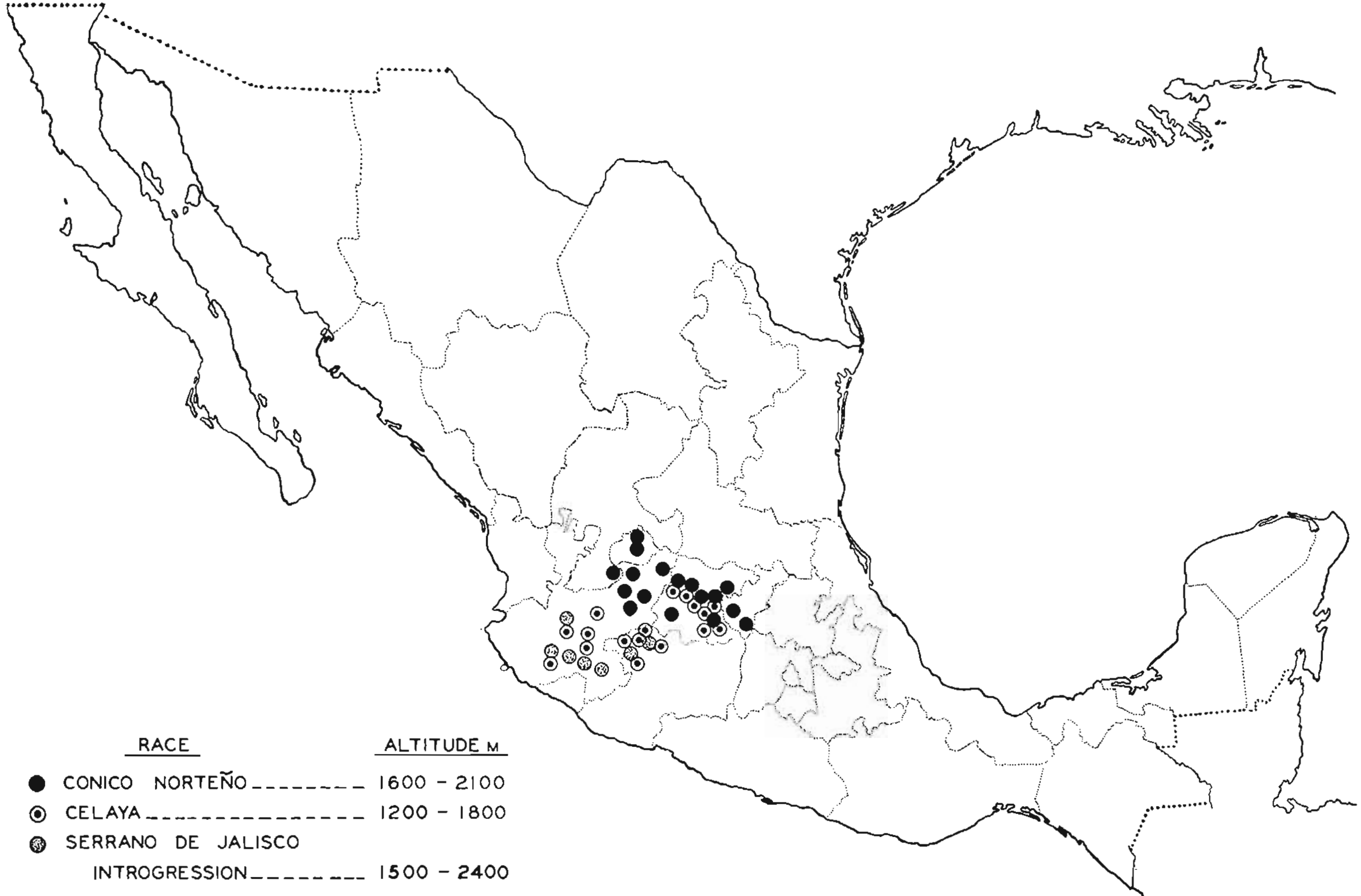


Fig. 107. Distribution of Cónico Norteño, Celaya and Celaya types showing introgression of "Serrano de Jalisco" (the Jaliscan mountain complex).

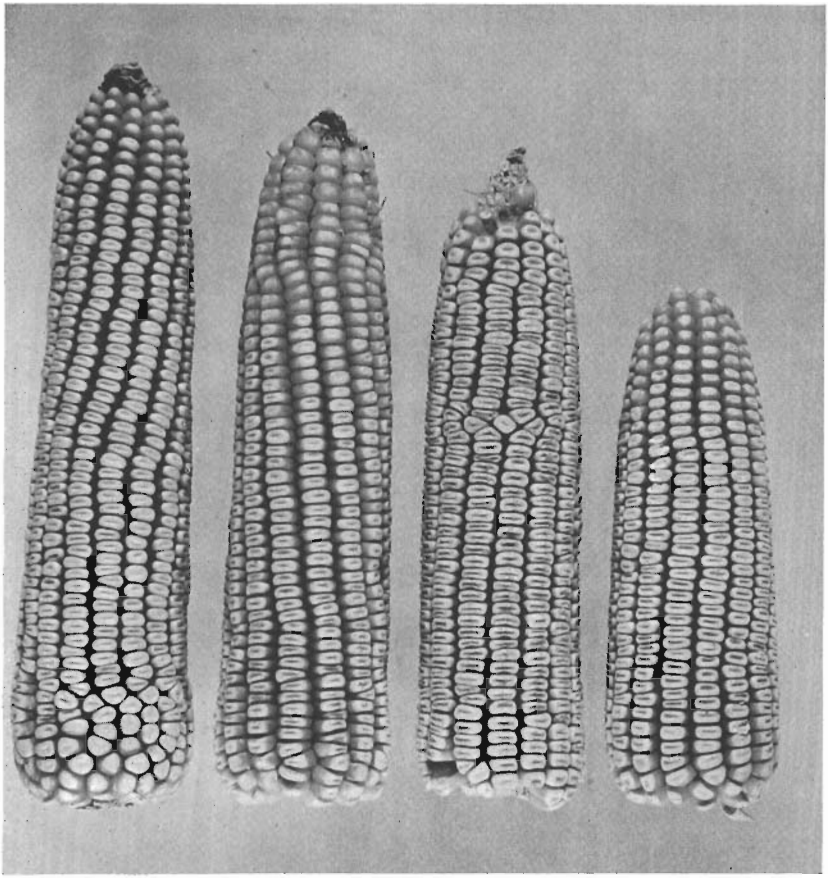


FIG. 108. Celaya — sub-race Argentino. The predominating form of Celaya from this area bordering Lake Chapala near Guadalajara is later and more vigorous than Celaya from the Central Bajío and has been designated as a sub-race Argentino. The ears of Argentino are slightly larger and have a slightly higher row number than those of Celaya proper. Scale 1 cm. = 2.38 cm.

index low, 0.19; pedicel hairs variable, few, short to long; cupule hairs variable, few to many, short to long; rachis flap intermediate to strong; lower glumes fleshy to horny, almost glabrous, few marginal hairs, the margins cordate; upper glumes fleshy, stiff, almost glabrous, few marginal hairs; tunicate alleles *tu* and tu^w; rachis tissue horny to bony; teosinte introgression intermediate to strong.

Distribution. Celaya is the predominant race in the area known as the "Bajio" (Fig. 6), often referred to as the "Corn Belt" of Mexico, at elevations from 1,200 to 1,800 meters. Its distribution is shown in Fig. 107 by the white circles with black centers. The geographical distribution of this race centers in the southern three-fourths of the state of Guanajuato around the towns of Celaya, Cortazar, Salamanca, Irapuato, Silao and Valle de Santiago, where besides being commonly known as "Celaya", it is sometimes referred to as "Kansas" and "Cuatero". It also extends to the west along the Lerma River and into the area surrounding Lake Chapala in the states of Michoacán and Jalisco. Varieties of this race generally grown around Lake Chapala are slightly later in maturity than those grown in the Bajio and have the common local name "Argentino" (Fig. 108). In Jalisco, the introgression between Celaya and the Jaliscan mountain complex is clearly evident. The distribution of varieties showing this introgression is plotted in Fig. 107 as stipled circles titled "Introgresion Serrano de Jalisco".

Being a productive and desirable agronomic type, the Celaya race has been extended to other areas in recent years through the distribution of outstanding varieties by various governmental agencies. It has become more or less common in Ameca, Jalisco, replacing Tabloncillo, and in the area around León and Querétaro it is replacing Cónico Norteño.

Origin and Relationships. Celaya, like Chalqueño, is a comparatively recent development for it has become prominent in the Bajio within historical times. It is one of the most productive agricultural races of Mexico and for a good reason, since it is undoubtedly a hybrid of two of the more productive races of Mexico, Tuxpeño and Tabloncillo. Celaya resembles either Tabloncillo or Tuxpeño or is intermediate between them in most of its characteristics (Table 10, Fig. 109 and Plate VII). It also can be readily synthesized by hybridizing these two races. Ears of the original and synthesized Celaya are illustrated in Fig. 110.

The probable genealogy of Celaya illustrated in Fig. 111 reveals why the race is so productive. Three different flour corns have entered into its ancestry and it has received teosinte genes from three different sources. Here is available for the corn breeder of

TABLE 10. Comparison of Celaya With Its Probable Progenitors, Tabloncillo and Tuxpeño.

	Tabloncillo	*Celaya*	*Tuxpeño*
Plant Characters			
Height (meters)	2.4	2.5	2.7
No. of Leaves	14.6	16.0	18.0
Width of Leaves (cm.)	8.6	8.9	10.5
Length of Leaves (cm.)	79.8	82.3	95.0
Venation Index	3.56	2.84	3.11
Tassel Characters			
Length (cm.)	40.0	42.4	42.6
Length of Branching Space (cm.)	9.0	12.6	14.4
Percent of Branching Space	23.0	28.0	30.0
No. of Branches	8.8	21.1	22.9
Percent Secondary Branches	11.5	16.8	20.5
Condensation Index	1.10	1.10	1.55
External Characters of Ear			
Length (cm.)	16.4	17.0	19.7
Diameter (cm.)	4.1	4.5	4.4
Row Number	9.1	12.4	12.6
Shank Diameter (mm.)	11.0	9.9	13.4
Width of Kernel (mm.)	11.5	9.1	9.3
Thickness of Kernel (mm.)	4.3	3.9	3.7
Length of Kernel (mm.)	10.3	12.9	12.8
Internal Characters of Ear			
Diameter of Cob (mm.)	23.4	23.3	26.5
Diameter of Rachis (mm.)	12.5	13.7	16.5
Length of Rachilla (mm.)	2.1	2.4	2.2
Cob/rachis Index	1.87	1.70	1.61
Glume/kernel Index	0.53	0.37	0.39
Rachilla/kernel Index	0.20	0.19	0.17
Pedicel Hairs	0–4	1–3	0–4
Rachis Flap	2–3	2–3	1
Rachis Induration	2	1–2	1+
Teosinte Introgression	2–3	2–3	3
Physiological, Genetic and Cytological Characters			
No. Days to Anthesis	107	116	148
Rust Resistance	1–2	1–2	3
Pilosity	1	1	1
Sheath Color	0–1	0–1	1–2
Mid-cob Color, Percent	54	67	58
Chromosome Knobs, Range	5–9	8–10	6–7
Average No.	7.6	8.5	6.1

Mexico, and perhaps the United States as well, some of the best maize germplasm in all of America.

Celaya does not "break up" as much as Chalqueño when inbred, which indicates that it may be an older race in which the germplasm derived from the various sources has now become

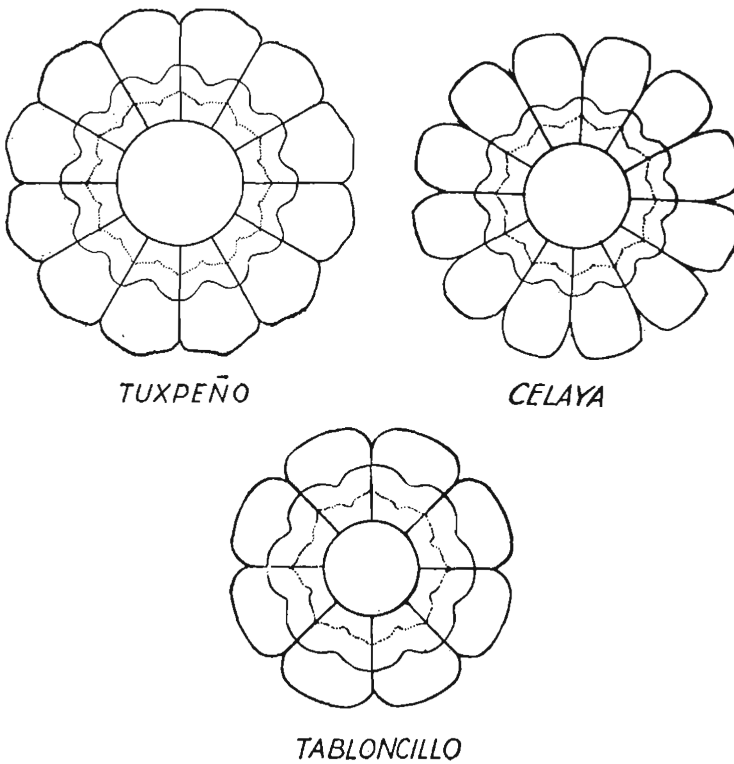


FIG. 109. A comparison of the diagrammatic ear cross sections of typical ears of Tuxpeño, Celaya and Tabloncillo.

thoroughly integrated. Some of the lowland varieties of San Luis Potosí are much like Celaya in their plant and ear characteristics. Celaya probably originated in the southern part of the Northern Mesa that extends into San Luis Potosí at elevations slightly lower than in the Bajio where it is now commonly grown. According to some of the older farmers in the Bajio, Celaya was first introduced about 30 or 40 years ago and was a much later corn then than it is now. It was probably first introduced from San Luis Potosí as

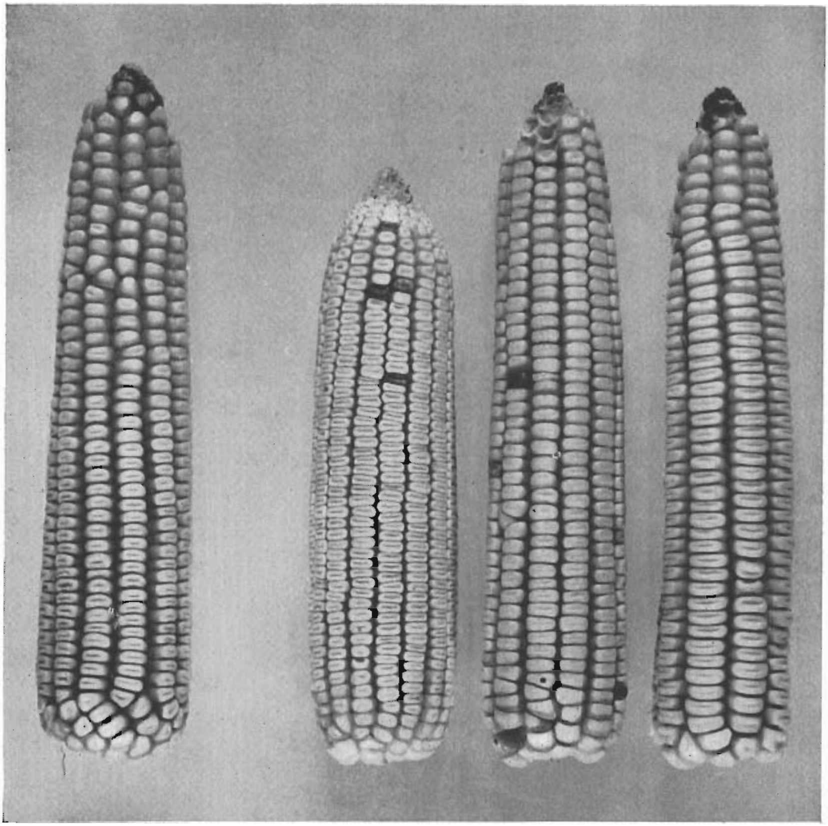


FIG. 110. Origin of Celaya. Celaya is intermediate in its characters between Tuxpeño and Tabloncillo which indicates its hybrid origin from these two parents; by experimentally crossing these two putative parents, a synthetic Celaya was produced that could not be distinguished from Celaya grown by farmers. Left to right (1) Celaya from a farmer's field, (2) the parent, Tuxpeño, (3) synthesized Celaya and (4) the other parent, Tabloncillo. Scale 1 cm. = 2.30 cm.

a corn better adapted to lower elevations but through continuous selection for earliness it now has developed into the modified form called Celaya. It is one of the most widely adapted types yet found, producing fairly well from elevations of about 800 meters to 1,800 meters.

Derivation of Name. From the name of the town Celaya, Guanajuato, which is located near the center of the region where this race is most commonly grown.

References. Chávez, 1913; Wellhausen, 1947.

CÓNICO NORTEÑO

Plants. Short; early; many tillers; number of leaves small, being wide in relation to length; venation index medium; color slight; pubescence slight to intermediate; medium resistant to rust; average number of knobs 8.0. Adapted to medium high elevations, 1,600–2,100 meters.

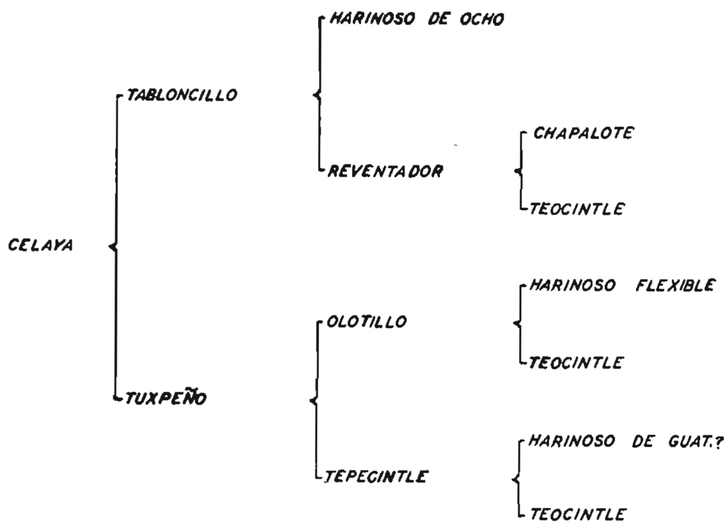


Fig. 111. The probable origin of Celaya.

Tassels. Intermediate to long; medium number of branches, frequent secondary and no tertiary branches; condensation index medium.

Ears, External Characters. (Fig. 112) Short to intermediate; medium uniform taper from base to tip; average number of rows 16.0; shank diameter medium small; mid-cob color in 56% of ears examined. Kernels narrow, thin and long, fairly well dented; striations slight; endosperm medium hard, white; aleurone and pericarp colorless.

Ears, Internal Characters. (Fig. 113) Ear diameter 45–48 mm.; cob diameter 22–24 mm.; rachis diameter 12–16 mm.; kernel length 13–16 mm.; estimated rachilla length 1.2 mm.; cob/rachis index low, 1.66; glume/kernel index low, 0.31; rachilla/kernel index low, 0.10; pedicel hairs variable, none to few long; cupule

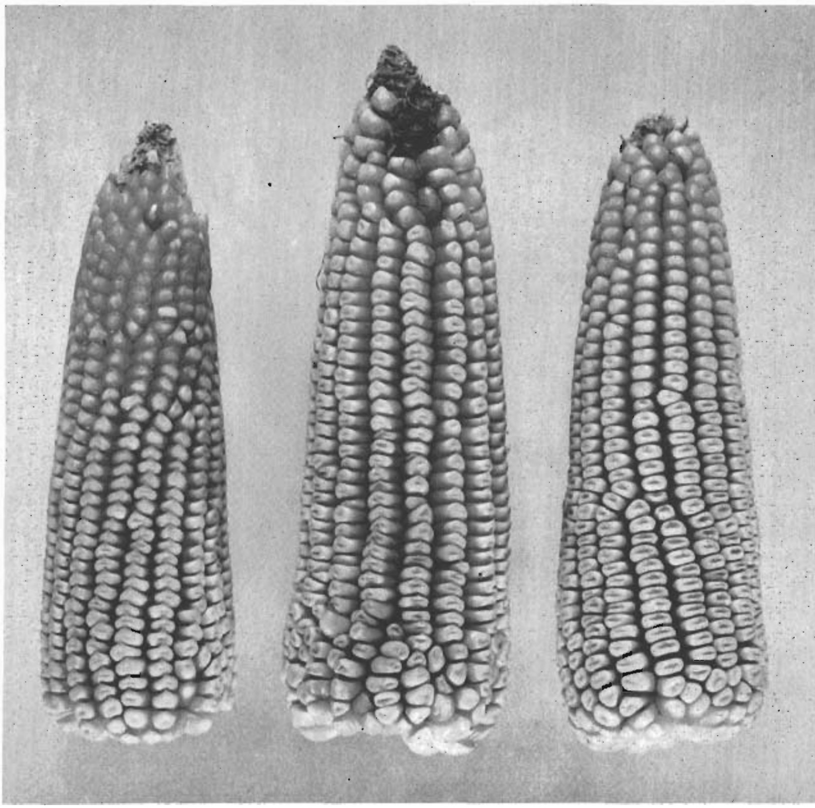
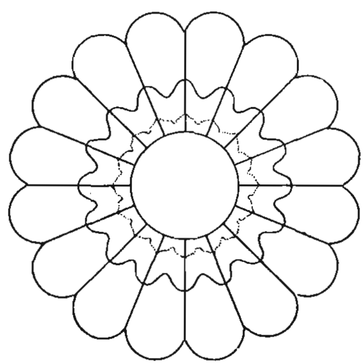


FIG. 112. Cónico Norteño. This race predominates in the northern part of the Bajío (Northern Jalisco, Aguascalientes, Guanajuato, Querétaro) at elevations of 1600 to 2100 meters. Note the short tapering ears that resemble those of the Cónico race of the Central High Plateau, to which Cónico Norteño is closely related. Scale 1 cm. = 1.76 cm.

hairs intermediate in number and length; rachis flap weak or absent; lower glumes fleshy, glabrous or almost so, few marginal hairs, the margins angulate; upper glumes fleshy with transparent margins, stiff, glabrous or almost so, marginal hairs few or none; tunicate allele *tu*; rachis tissue horny; teosinte introgression intermediate.

Distribution. Cónico Norteño has been found to be extensively grown in the region known as the northern Bajio at elevations from 1,600–2,100 meters although it is best adapted to altitudes from 1,800–2,000 meters in this area. The northern Bajio (Fig.

6) includes the northern parts of the states of Jalisco (Los Altos de Jalisco) and Guanajuato and practically all of Aguascalientes and Querétaro. Locations where this race has been collected are shown in Fig. 107 by solid black circles. Although not shown on the map, it probably extends into the highlands of San Luis Potosí, Zacatecas and Hidalgo. At one time it was undoubtedly prevalent in the Bajio at elevations between 1,500 and 1,800 meters, the area now occupied principally by Celaya.



CONICO NORTEÑO

FIG. 113.

Origin and Relationships. Cónico Norteño undoubtedly originated from the Cónico race of the Mesa Central having been modified by the introduction of genes from Celaya or its precursors Tuxpeño and Tabloncillo. In a majority of its characteristics it more closely resembles its Cónico parent (Table 11), and this relationship is especially evident in the general appearance of the ears (Figs. 30 and 112) and in the diagrammatic cross sections (Fig. 114) and internode patterns, Plate VII. In the rachilla/kernel index, Cónico and Cónico Norteño are almost identical and, like Pepitilla, they show a relationship to the primitive Palomero Toluqueño in this characteristic. Certain varieties of Cónico Norteño show modifications such as thicker ear with long kernels with a tendency to have beaks at the apex, characteristics which, in more accentuated form, are found in Pepitilla (Fig. 115). This does not mean, however, that these varieties are necessarily directly related to Pepitilla; they may have obtained their

TABLE 11. Comparison of Cónico Norteño With Cónico and Celaya.

	Cónico	*Cónico Norteño*	*Celaya*
Plant Characters			
Height (meters)	1.7	2.0	2.5
No. of Leaves	11.2	12.8	16.0
Width of Leaves (cm.)	8.2	7.9	8.9
Length of Leaves (cm.)	72.0	74.6	82.3
Venation Index	2.78	2.93	2.84
Tassel Characters			
Length (cm.)	34.5	40.3	42.4
Length of Branching Space (cm.)	4.5	10.2	12.6
Percent of Branching Space	14.0	25.0	28.0
No. of Branches	5.5	17.5	21.1
Percent Secondary Branches	7.0	18.3	16.8
Condensation Index	2.58	1.38	1.10
External Characters of Ear			
Length (cm.)	13.6	13.1	17.0
Diameter (cm.)	4.3	4.6	4.5
Row Number	16.0	16.0	12.4
Shank Diameter (mm.)	8.8	11.3	9.9
Width of Kernel (mm.)	6.6	7.3	9.1
Thickness of Kernel (mm.)	3.6	3.5	3.9
Length of Kernel (mm.)	14.8	14.9	12.9
Internal Characters of Ear			
Diameter of Cob (mm.)	19.0	23.3	23.3
Diameter of Rachis (mm.)	9.6	14.0	13.7
Length of Rachilla (mm.)	1.6	1.2	2.4
Cob/rachis Index	1.98	1.66	1.70
Glume/kernel Index	0.32	0.31	0.37
Rachilla/kernel Index	0.11	0.10	0.19
Pedicel Hairs	2–4	0–3	1–3
Rachis Flap	2–3	1	2–3
Rachis Induration	0	1	1–2
Teosinte Introgression	0	2	2–3
Physiological, Genetic and Cytological Characters			
No. Days to Anthesis	90	98	116
Rust Resistance	1	1–2	1–2
Pilosity	3–4	1–2	1
Sheath Color	4–5	1	0–1
Mid-cob Color, Percent	39	56	67
Chromosome Knobs, Range	—	—	8–10
Average No.	1.0	8.0	8.5

Pepitilla-like seeds directly from Palomero Toluqueño. The influence of Celaya or its putative parents is most easily noted in the modifications it has brought about in the plant and tassel characteristics. Cónico Norteño is more like Celaya than Cónico in the general appearance of the tassel, the amount of sun-red

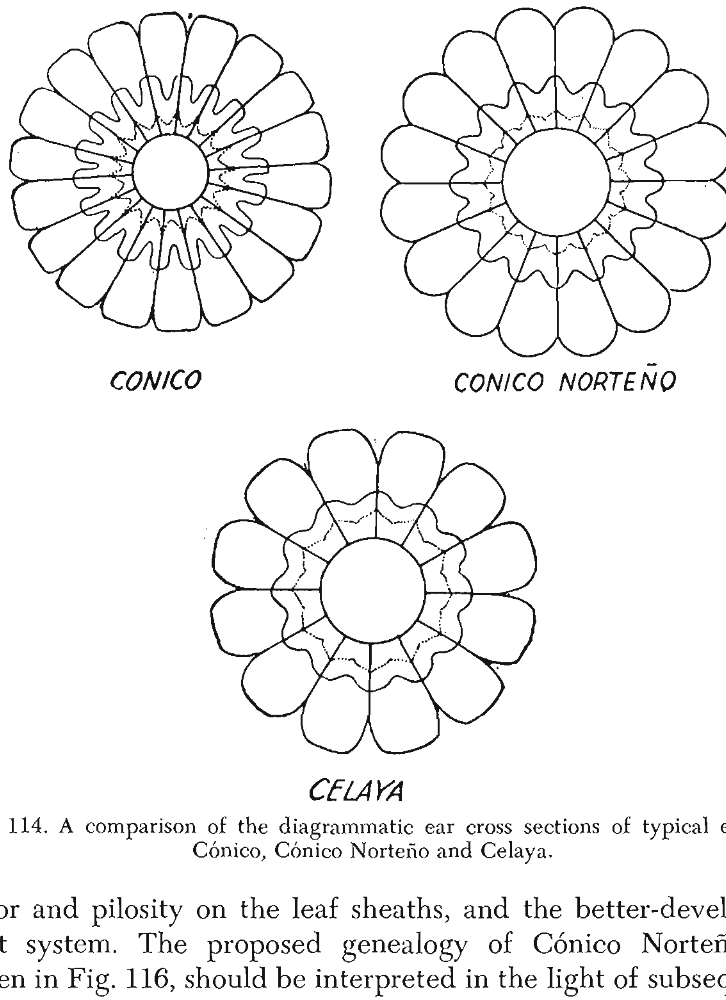


FIG. 114. A comparison of the diagrammatic ear cross sections of typical ears of Cónico, Cónico Norteño and Celaya.

color and pilosity on the leaf sheaths, and the better-developed root system. The proposed genealogy of Cónico Norteño as given in Fig. 116, should be interpreted in the light of subsequent discussion. There is no doubt that Cónico Norteño has germplasm in common with Celaya. It is not so certain that Celaya was actually the parent, although a counterpart of Cónico Norteño resembling it to a remarkable degree has been synthesized by

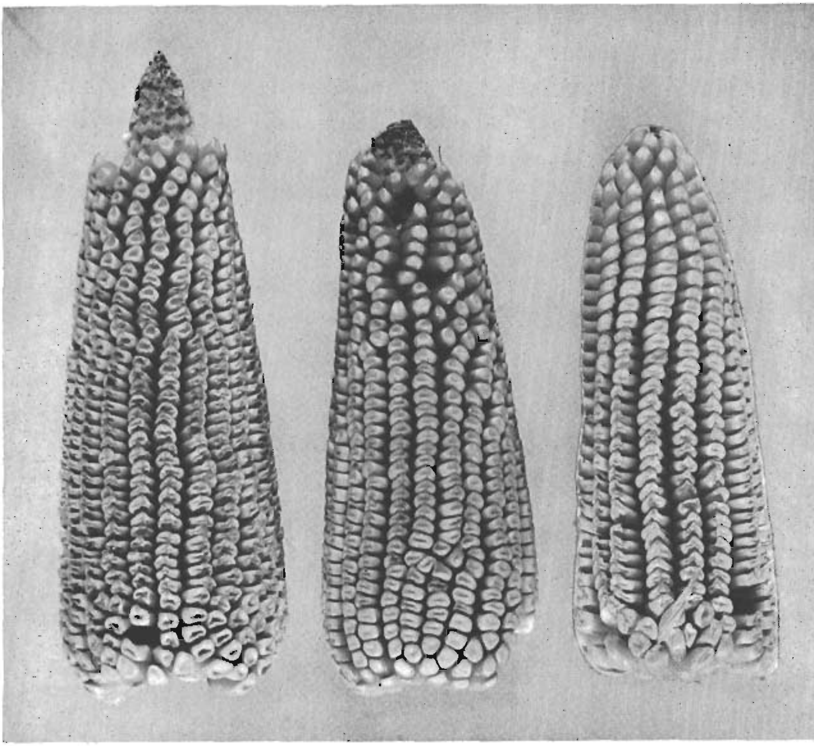


FIG. 115. Cónico Norteño (Pepitilla Type). Some varieties of Cónico Norteño (locally called Pepitilla) show modifications such as a thicker ear with long kernels with a tendency to have beaks at the apex, resembling Pepitilla.
Scale 1 cm. = 2.03 cm.

crossing Cónico and Celaya. A comparison of the experimentally produced ears with those of the original race is illustrated in Fig. 117. Approximately this same degree of resemblance exists between the plants of the synthetic and original Cónico Norteño.

Although at the present time there is a strong introgression of Celaya from the Bajio into Cónico Norteño, evidence strongly indicates that Cónico Norteño did not develop from the Bajio introgression. Cónico Norteño already existed and was the predominating type in the Bajio before Celaya was introduced. The probability that Celaya was developed in the Bajio from an introduction of varieties derived from the hybridization of Tuxpeño and Tabloncillo elsewhere, probably in San Luis Potosí, has already been discussed. Either Cónico Norteño developed from the separate introgression of Tabloncillo and Tuxpeño into Cónico or from the direct introgression of varieties that were derived from the hybridization of Tuxpeño and Tabloncillo in some region other than the Bajio. That Cónico Norteño may have developed by the separate introgression of Tabloncillo and Tuxpeño is supported by its present geographical distribution (Fig. 107). It is found principally at 1,800 to 2,000 meters elevation, overlapping Cónico,

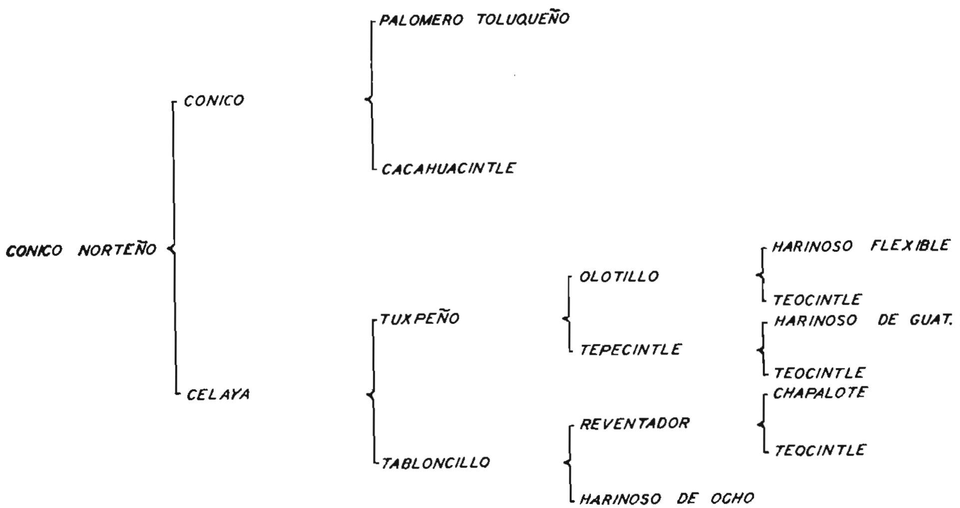


FIG. 116. The probable origin of Cónico Norteño.

in the narrow strip of highlands (Fig. 6) separating the Jaliscan plains on the south with its predominating Tabloncillo types, and the southern part of the Northern Mesa on the north not far from the Gulf Plains with its types predominately Tuxpeño. Since there is no evidence that Cónico Norteño has taken part in the formation of other races, it probably is of recent origin.

Derivation of Name. One of the most distinctive features of this race is the conical shaped ears and since its distribution is in the northern part of the Bajio it was given the name Cónico Norteño to distinguish it from the Cónico race of the Central Mesa.

References. Chávez, 1913; Montelongo, 1938; Wellhausen, 1947.

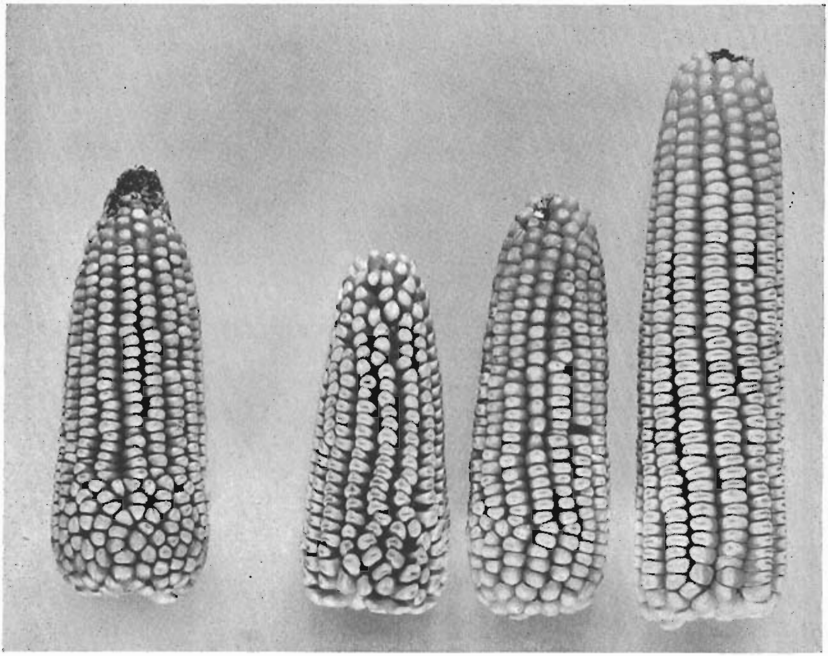


FIG. 117. Origin of Cónico Norteño. Cónico Norteño is basically Cónico from the Central High Plateau that has been modified through hybridization with Celaya. It is possible to reproduce this race by crossing these two parents as shown in this photograph. From left to right (1) original ear of Cónico Norteño, (2) Cónico parent (3) synthesized ear of Cónico Norteño and (4) Celaya parent. Scale 1 cm. = 2.52 cm.

BOLITA

Plants. Medium short; early; few tillers; intermediate number of leaves which are wide in relation to length; high venation index; color almost lacking; pubescence very slight; medium resistance to rust; medium number of knobs, average 8.6. Adapted to medium elevations, 900–1,500 meters.

Tassels. Medium long; number of branches intermediate to high; percentage of secondary branches intermediate, tertiary branches rare; condensation index low.

Ears, External Characters. (Fig. 118) Very short, cylindrical; average number of rows 10.2; shank diameter small; mid-cob color present in 40% of ears examined. Kernels medium wide, thick, short, denting pronounced; slight to medium striations; endosperm medium hard, white; aleurone and pericarp colorless.

Ears, Internal Characters. (Fig. 119) Ear diameter 42–48 mm.; cob diameter 25–30 mm.; rachis diameter 14–19 mm.; length of kernels 11–13 mm.; estimated rachilla length 2.5 mm.; cob/rachis index low, 1.70; glume/kernel index low, 0.45; rachilla/kernel index low, 0.20; pedicel hairs few, long; cupule hairs many, short; rachis flap intermediate to strong; lower glumes horny, almost

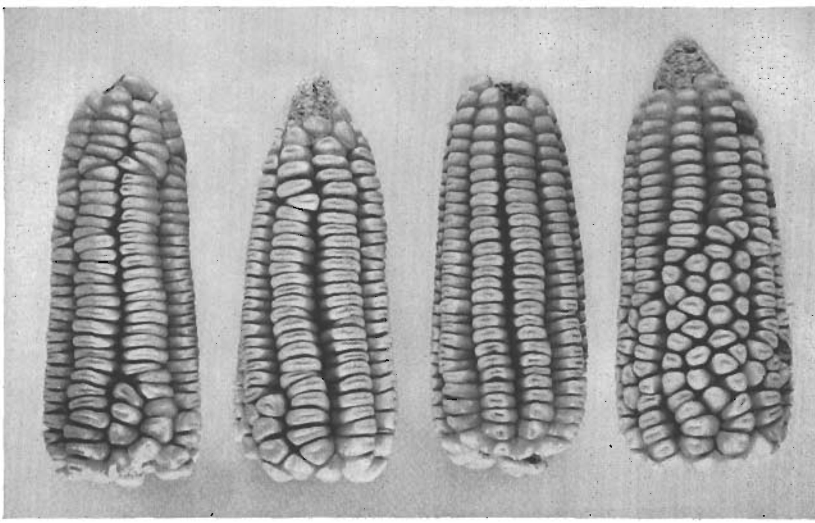


FIG. 118. Bolita. Very short ears with heavy husk covering are characteristics of the race Bolita, the common corn of the valley of Oaxaca. The ears have few rows and wide spacing between the rows. The plants are short and early in maturity. Scale 1 cm. = 2.41 cm.

glabrous, marginal hairs many long, the margins undulate; upper glumes chaffy to fleshy with transparent margins; stiff, glabrous or slightly hairy, few long marginal hairs; tunicate allele tu^w; rachis tissue horny; teosinte introgression intermediate.

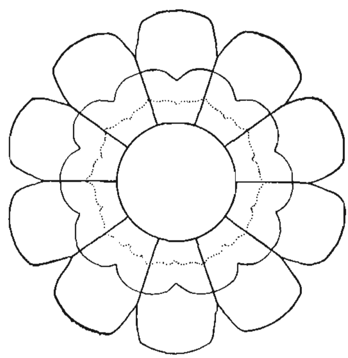
Distribution. Bolita is very common in the central mesa of Oaxaca at elevations of 900 to 1,500 meters. Its distribution is shown by the solid black circles in Fig. 57. Certain varieties in northern Oaxaca and in Puebla at elevations from 1,000 to 1,500 meters show a strong introgression of Bolita (Fig. 57, circles with black spots in center). At lower elevations to the south, the introgression into Zapalote Chico or vice-versa is also evident although not shown on the distribution maps. Collections of the purer forms

TABLE 12. Comparison of Bolita With Zapalote Chico and Tabloncillo.

	Zapalote Chico	*Bolita*	*Tabloncillo*
Plant Characters			
Height (meters)	1.2	2.0	2.4
No. of Leaves	10.0	13.5	14.6
Width of Leaves (cm.)	7.9	9.2	8.6
Length of Leaves (cm.)	64.2	77.8	79.8
Venation Index	3.30	3.14	3.56
Tassel Characters			
Length (cm.)	34.0	40.4	40.0
Length of Branching Space (cm.)	10.7	11.7	9.0
Percent of Branching Space	34.0	29.0	23.0
No. of Branches	18.9	17.4	8.8
Percent Secondary Branches	16.0	19.0	11.5
Condensation Index	1.72	1.27	1.10
External Characters of Ear			
Length (cm.)	9.9	11.6	16.4
Diameter (cm.)	4.2	4.2	4.1
Row Number	10.7	10.2	9.1
Shank Diameter (mm.)	13.7	9.8	11.0
Width of Kernel (mm.)	9.8	10.4	11.5
Thickness of Kernel (mm.)	3.6	4.1	4.3
Length of Kernel (mm.)	10.1	12.3	10.3
Internal Characters of Ear			
Diameter of Cob (mm.)	23.3	26.7	23.4
Diameter of Rachis (mm.)	14.0	15.7	12.5
Length of Rachilla (mm.)	3.7	2.5	2.1
Cob/rachis Index	1.66	1.70	1.87
Glume/kernel Index	0.46	0.45	0.53
Rachilla/kernel Index	0.37	0.20	0.20
Pedicel Hairs	0–1	3	0–4
Rachis Flap	1	2–3	2–3
Rachis Induration	1–2	1+	2
Teosinte Introgression	3	2	2–3
Physiological, Genetic and Cytological Characters			
No. Days to Anthesis	96	98	107
Rust Resistance	4–5	2	1–2
Pilosity	0–1	1	1
Sheath Color	2	1	0–1
Mid-cob Color, Percent	18	40	54
Chromosome Knobs, Range	10–14	7–11	5–9
Average No.	11.7	8.6	7.6

have been made from the valley of Oaxaca which is probably the center of distribution and from Teotitlan del Valle, Santiago Matatlan, San José de Gracia, Huajuapan, Etla, Tamazula, Nochixtlán, San Juan Chilateca and Zaachila.

Origin and Relationships. Bolita is probably derived from the hybridization of Zapalote Chico and Tabloncillo. Something very much like it has been produced artificially as the result of hybridizing these two races (Fig. 120), and Bolita itself, from a study of



BOLITA

FIG. 119.

the data presented in Table 12, Fig. 121 and Plate VII, gives the impression of blending the characteristics of these two putative parental races in approximately equal proportions. This evidence, together with the fact that on inbreeding the putative parental types occasionally reappear among the segregates, makes the genealogy of Bolita in Fig. 122 almost certain. Its very restricted distribution would indicate that it is either a relict of great antiquity or a new race of recent origin. The latter alternative appears to be the more plausible, especially since there is little or no evidence that this race has entered into the ancestry of other races in Mexico.

Derivation of Name. This is a common local name for this race in the central valley of Oaxaca where it predominates. Bolita means "little ball" in Spanish and refers to the round appearance of the ear when it is enclosed in its husk.

References. Chávez, 1913.

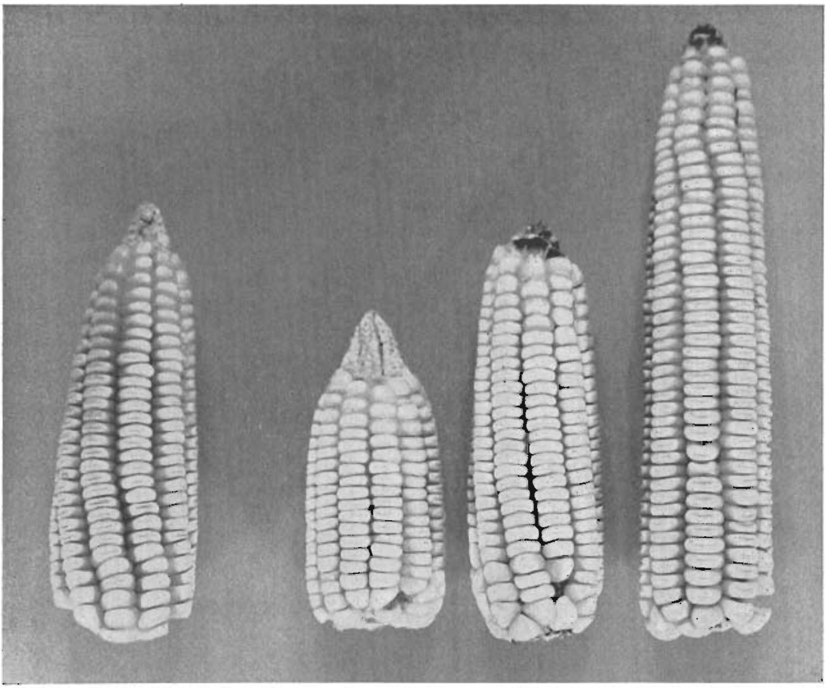


FIG. 120. Origin of Bolita. The origin of Bolita as a hybrid between Zapalote Chico and Tabloncillo is fairly well established since ears of this race have been essentially duplicated by experimental crossing of these two parents. Left to right (1) ear of Bolita collected in the field, (2) Zapalote Chico, (3) synthetic Bolita and (4) Tabloncillo. Scale 1 cm. = 2.52 cm.

POORLY DEFINED RACES

Races or types which have been recently collected or on which insufficient data have been accumulated to warrant a classification and genealogy with a reasonable degree of certainty are grouped here under the heading of Poorly Defined Races. Their names, together with their description, distribution and origin insofar as the data will permit, are given below:

CONEJO

A type of corn whose ears are illustrated in Fig. 123 has been repeatedly found throughout the Balsas River Basin in the states of Michoacán and Guerrero at 200 to 350 meters elevation. It is very early in maturity, often called "Tres Mezino" (meaning three months); fairly short in plant growth, from 1.6 to 1.9 meters in height at Chapingo; ears are from 5 to 7 inches long with 8–10 rows of medium size grain and borne fairly low on stalk. One of the parents without doubt is Nal-Tel. The other could be Tabloncillo but more information is needed before this can be determined.

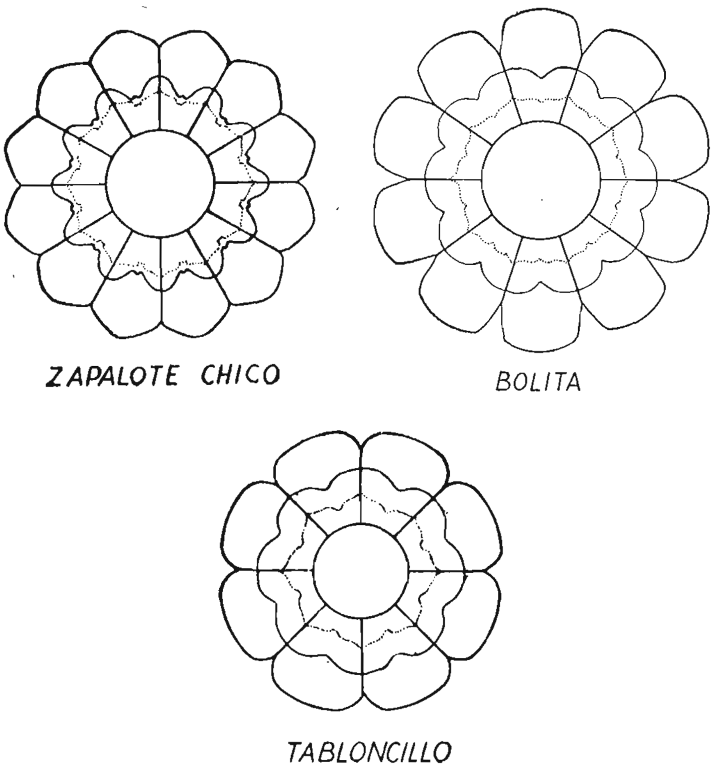


FIG. 121. A comparison of the diagrammatic ear cross sections of typical ears of Zapalote Chico, Bolita and Tabloncillo.

MUSHITO

Mushito is a very productive late corn grown at 2,400 meters elevation near Suchixtepec, Oaxaca. Typical ears shown in Fig. 124 are mostly cylindrical in shape, 6 to 8 inches long, with 10 to 12 rows of well dented kernels. It may be a modern type in some way derived from Comiteco.

COMPLEJO SERRANO DE JALISCO

In the southern part of the state of Jalisco there is a relatively small, high mountain area that extends into northern Colima including the "Volcán de Colima" (Fig. 6, shaded area projecting into the southern part of the Altiplanicie de Jalisco). In this area samples of corn have been collected from an elevation of 2,700 meters, close to the upper limit of corn cultivation, in the area

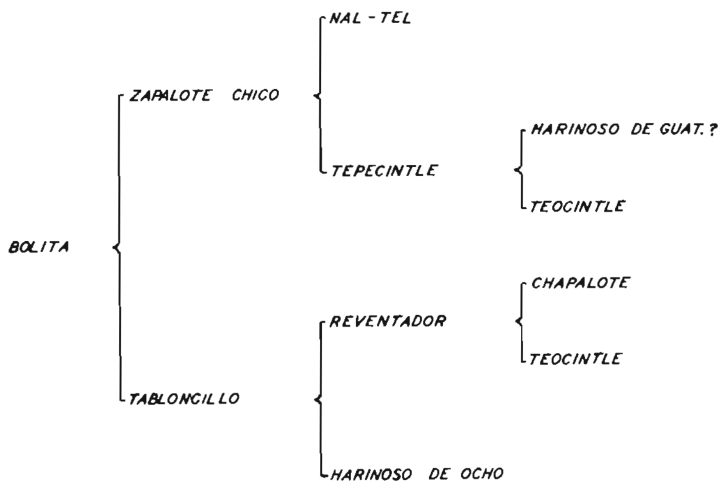


FIG. 122. The probable origin of Bolita.

down to 1,500 meters where the mountains level off into the plains of Jalisco. From a preliminary study of these samples it appears that the corns of the area resulted from the inter-hybridization of three races; namely, Palomero Toluqueño, Olotón and Tabloncillo. Types found at 2,660 meters were largely Palomero Toluqueño with an introgression of Olotón and resembling in part the high altitude Cónicos of the Mesa Central. Around 2,200 meters near Juanacatlan the varieties seemed to contain more Olotón in relation to Palomero Toluqueño. They were very late in maturity and very resistant to frost according to the farmers of the area. Also the grain was considered to be very heavy in relation to unit volume. Farther down the mountain at elevations around 1,800 meters the introgression of Tabloncillo became strongly evident.

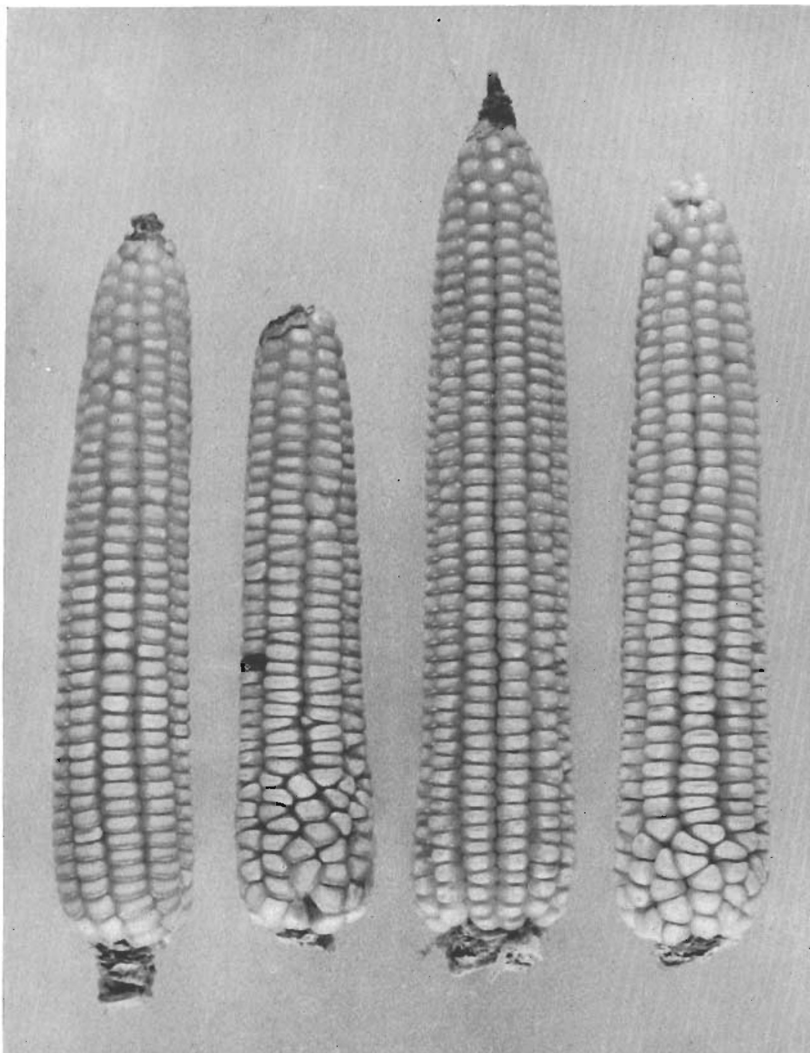


FIG. 123. Maíz Conejo. An early maturing type found throughout the lowlands of Michoacán and Guerrero. One of its parents without doubt is Nal-Tel, the other has not yet been determined. Scale 1 cm. = 1.74 cm.

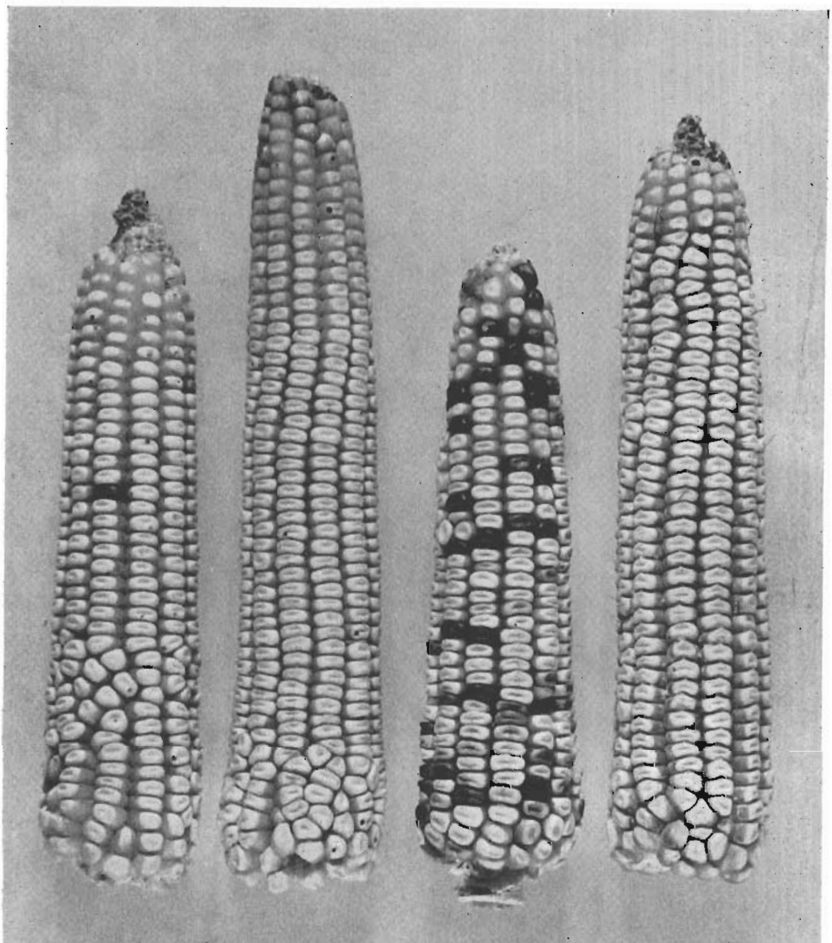


FIG. 124. Mushito. A very productive late corn grown at 2400 meters elevation near Suchixtepec, Oaxaca. Scale 1 cm. = 2.13 cm.

Most of the varieties collected in this mountain area were extremely variable and no distinct races could be defined. Common ear colors were white, yellow, red and gradations of reddish-yellow. Some of the ears typical of the area are shown in Fig. 125. The two ears shown at the left were more common at the higher

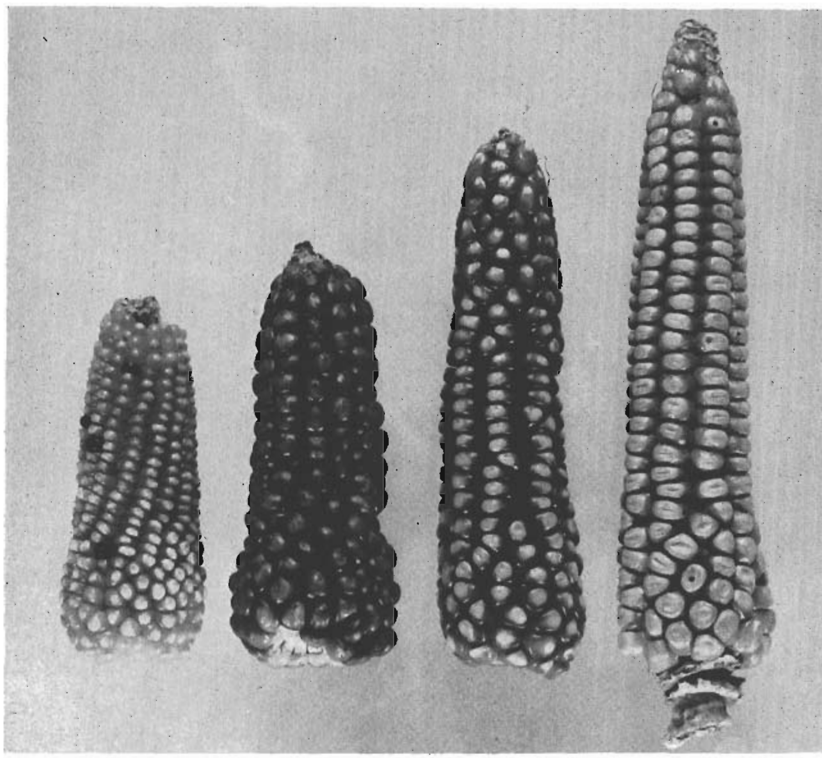


FIG. 125. Complejo Serrano de Jalisco. Ears typical of the southern mountain area of Jalisco. The two ears shown at left are typical of those common at the higher elevations, whereas the two at the right are more characteristic of the lower elevations. Scale 1 cm. = 1.99 cm.

elevations whereas the two at the right were more common at the lower elevations in this mountain region. The ear on the extreme right is similar to the type described by Anderson (1946a) as "Mountain Yellow". It was collected at 1,800 meters elevation near Tapalpa, Jalisco.

The influence of the corns in this Jaliscan mountain area on other races, especially in the western Cónicos, has already been pointed out. Its influence is also evident on many of the Tabloncillo types in the Altiplanicie de Jalisco bordering these mountains.

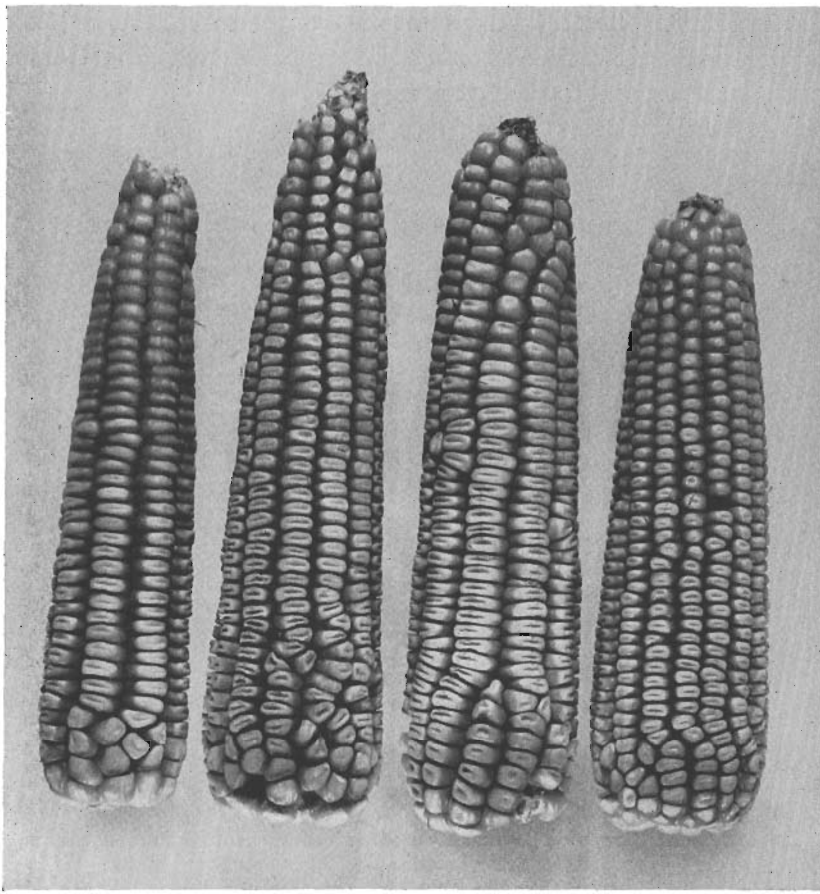


FIG. 126. Zamorano Amarillo. A very productive yellow corn found principally in the valley of Zamora in Michoacán. Scale 1 cm. = 1.98 cm.

ZAMORANO AMARILLO

Zamorano Amarillo is a very productive yellow corn found principally in the valley of Zamora at 1,500 meters elevation in the state of Michoacán. Judging from the appearance of its ears (Fig. 126) and from the results of inbreeding, at least four basic types have been involved in its derivation; namely, (1) western Cónico;

(2) Jaliscan Mountain Complex which contains Olotón; (3) Tabloncillo; and (4) Cylindrical dent, either Tuxpeño or Vandeño. Some of the genes attributed to Tabloncillo and Tuxpeño may have been derived through Celaya. Very few good lines have been obtained from inbreeding this type, most of them being susceptible to lodging and ear rots as might be expected from the Cónico germplasm which the race contains.

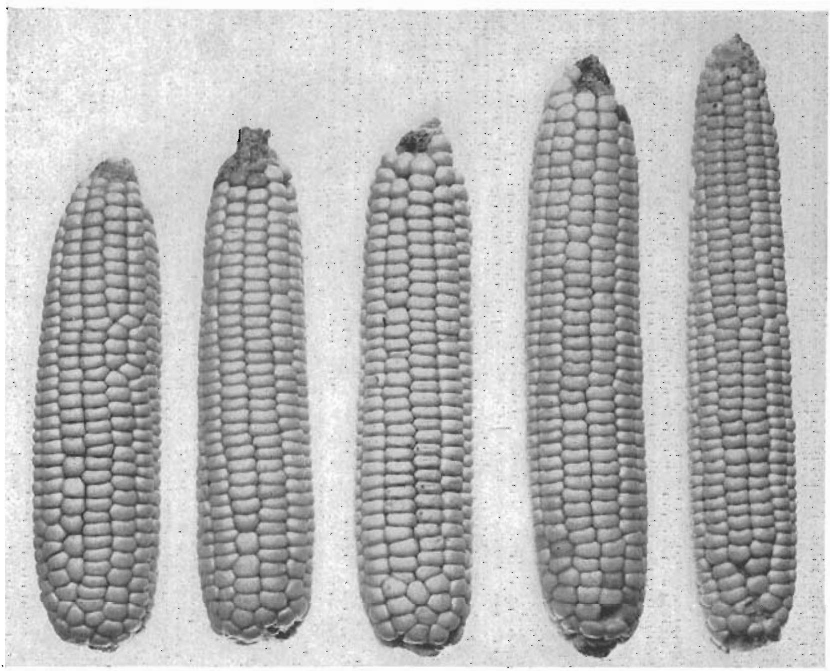


FIG. 127. Maíz Blando de Sonora. Flour corns common in the state of Sonora. Scale 1 cm. = 2.64 cm.

MAÍZ BLANDO DE SONORA

In a recent collecting expedition to Sonora the flour corn illustrated in Fig. 127 was found to be common in certain parts of the state. It was collected from the following villages at elevations up to 500 meters: Ures, Sahuaripa, Mazatan, Moctezuma, Suaqui, Santa Ana, Cocospero, Metape and Bacanora. It differs from the eight-rowed, wide-grained flour corn previously described as Harinoso de Ocho in having a shorter ear, bigger cob, higher row num-

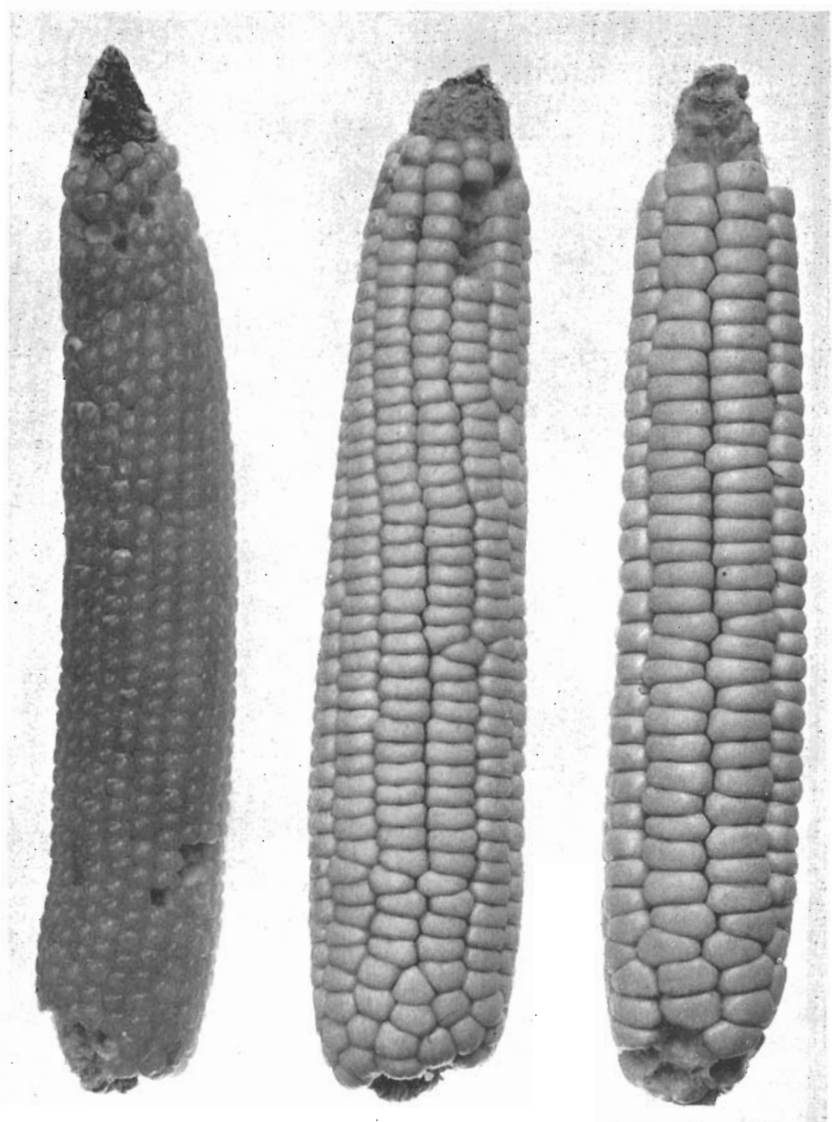


FIG. 128. Origin of Maíz Blando de Sonora. The flour corns of Sonora probably were derived from the introgression of Chapalote and Reventador into Harinoso de Ocho. Ears from left to right (1) Reventador, (2) Maíz Blando de Sonora and (3) Harinoso de Ocho. Scale 1 cm. = 1.37 cm.

ber and smaller grain. It is very similar to the prehistoric maize from "Cañón del Muerto" described by Anderson and Blanchard (1942) which dates back to between 500 and 700 A.D. Ears practically identical in appearance with those illustrated by Anderson and Blanchard were collected in Sonora. "Maíz Blando" in Sonora

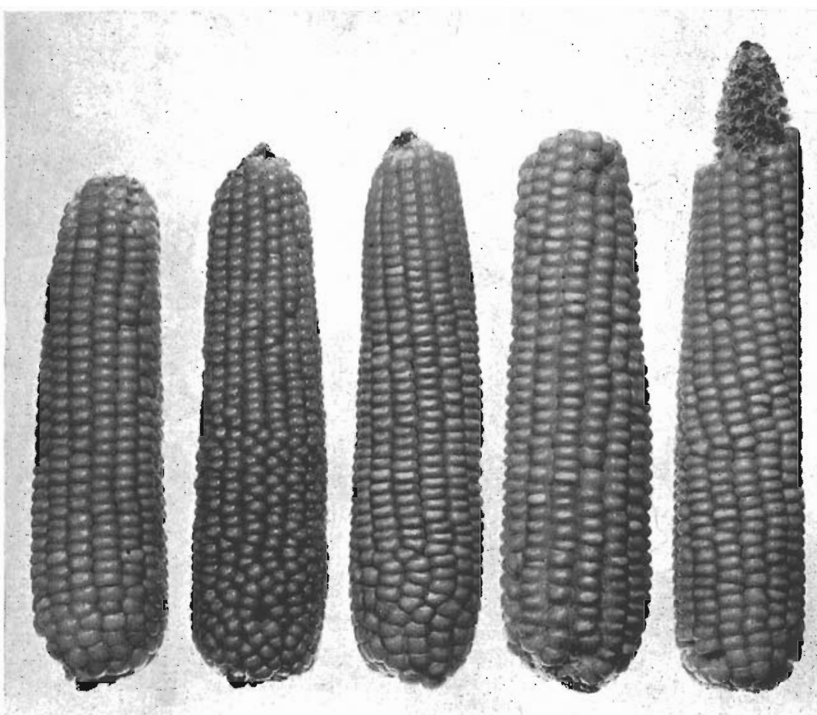


FIG. 129. Onaveño. A type of flint corn distributed throughout the same area as Maíz Blando in Sonora. Scale 1 cm. = 2.89 cm.

is also very similar to the Pima-Papago corns of southern Arizona in the United States described by Anderson and Cutler (1942) and Carter and Anderson (1945). These flour corns in Sonora and southern Arizona probably derived from the introgression of Chapalote and Reventador into Harinoso de Ocho (Fig. 128).

ONAVEÑO

This is the common name used for a type of flint corn distributed throughout the same area as Maíz Blando in Sonora. Typical ears of *Onaveño are illustrated in* Fig. 129. Some of the varieties may be the result of the introgression of Reventador into Maíz Blando, both of which are found in the same area with Onaveño. On the other hand, others may be nothing more than Maíz Blando with genes for flinty endosperm. A type illustrated in Fig. 130 collected from Chihuahua is somewhat different from Onaveño in having a longer, thicker ear, bigger cob, larger and softer grains slightly dented and may represent Onaveño modified by some other complex yet unidentified.

DULCILLO DEL NOROESTE

A sweet corn quite different from Maíz Dulce of Jalisco has been found throughout Sonora in the same areas as Maíz Blando, Onaveño and Reventador. Typical ears of this northwestern sweet corn are shown in Fig. 131. It differs from Maíz Dulce of Jalisco (Fig. 27) in having a longer and more slender ear generally tapering at both ends and in having smaller pale yellow grains. It also differs from the common Maíz Dulce of Jalisco in adaptation to altitude. The northwestern sweet corns are primarily adapted to the lowland dry tropics whereas Maíz Dulce of Jalisco is commonly grown at about 1,500 meters and has produced fairly normal ears up to 2,200 meters elevation. It is probable that the northwestern sweet corns originated from the hybridization of Maíz Dulce and Reventador. In many respects the ears show a strong resemblance to Reventador. Also some of the varieties of sweet corn found at low elevations in Nayarit resembled very closely the northwestern sweet corns in ear type but in color of the dried grains varied from pale yellow to bright orange-yellow to deep red, which is the color range most typical of Máiz Dulce in Jalisco.

THE CLASSIFICATION OF MAIZE IN RELATION TO ITS IMPROVEMENT

Although the classification of maize in Mexico is of principal importance from the standpoint of the botany and history of maize, and to a lesser extent for whatever light it may shed upon anthropological problems in Mexico, it also offers promise of

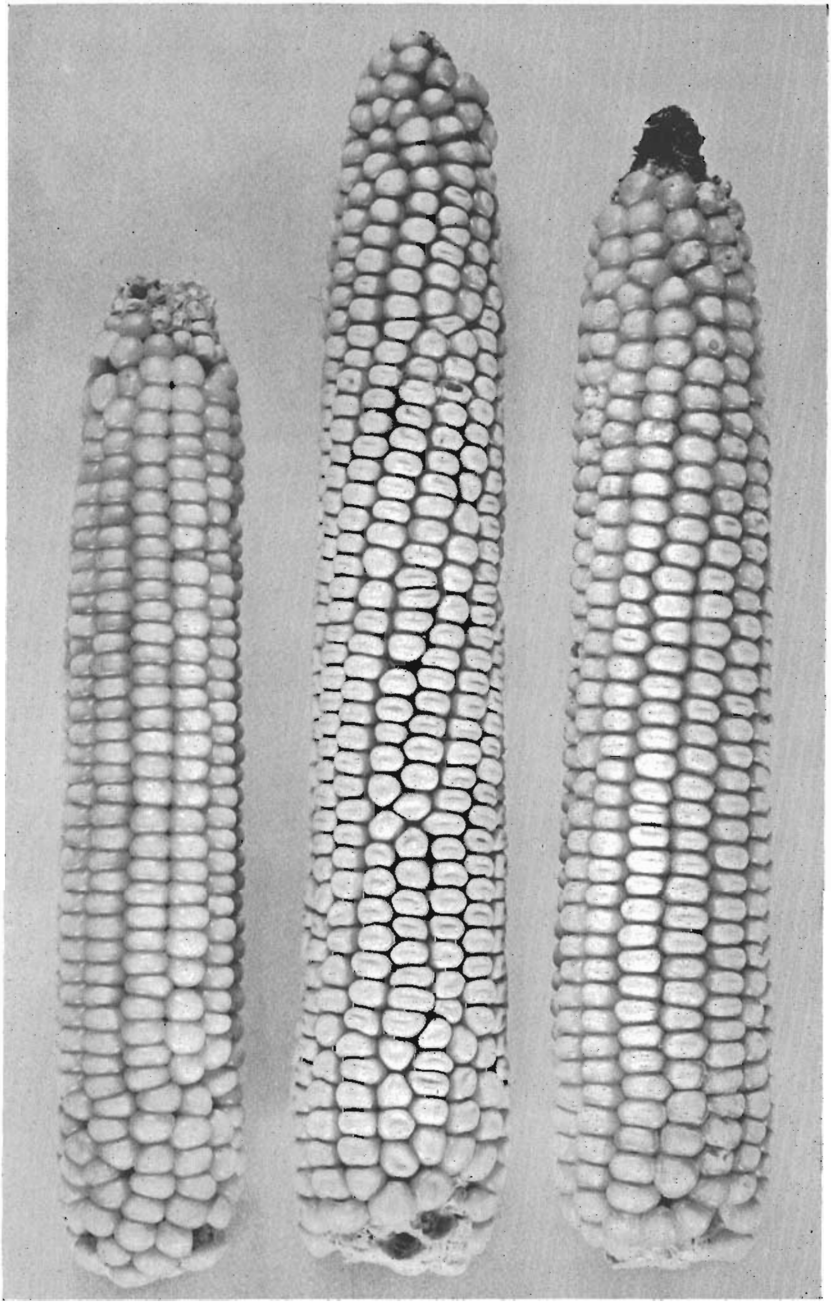


FIG. 130. Maíz Cristalino de Chihuahua. This type of flint corn collected in Chihuahua is somewhat different from Onaveño in having a longer, thicker ear, bigger cob and larger grains with a slight dent. Scale 1 cm. = 1.82 cm.

being quite useful in the improvement of maize not only in Mexico but also in the United States. A comprehensive natural classification is more than an array of pigeonholes into which races may conveniently be placed. It should reveal relationships and paths of origin and should provide an inventory of the kinds of germplasm available to the plant breeder. For example, it is becoming increasingly apparent that the majority of the more productive agricultural races of Mexico are those which have

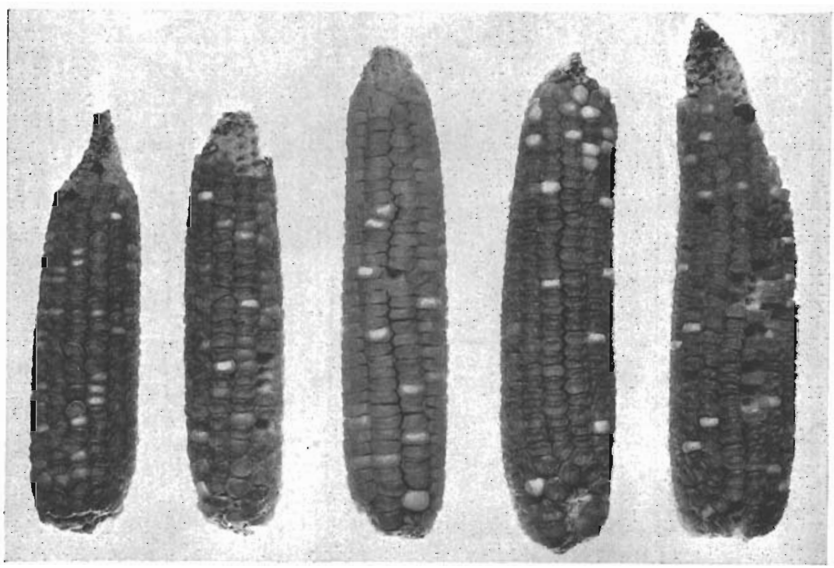


Fig. 131. Dulcillo del Noroeste. A sweet corn common in Sonora that may have originated from the hybridization of the "Maíz Dulce" common in Jalisco, and Reventador. Scale 1 cm. = 2.57 cm.

been derived through hybridization with the cylindrical dents, represented on the west coast of Mexico by the race Vandeño and on the east coast by the race Tuxpeño. This fact is now so well established that corn breeders working toward the development of hybrid corn for the Mesa Central of Mexico for example are confronted with two alternatives. They must either isolate inbred strains from varieties which already show admixture with Tuxpeño or Vandeño or they must develop inbred strains from those races which are suitable for combining with inbred strains of the race Cónico now commonly grown. Knowing the characteristics of all of the races involved it now seems that the greatest immediate progress can be made by following the first course. However, once a point of diminishing returns has been reached on this course, opportunities for still further and perhaps even greater progress are available in following the second.

A similar situation exists in the United States. The maize of the Corn Belt is undoubtedly the result of hybridization of Northern Flints and Southern Dents. There is historical evidence for this conclusion (Wallace and Bressman, 1928) and new botanical evidence in support of it has recently been presented by Brown

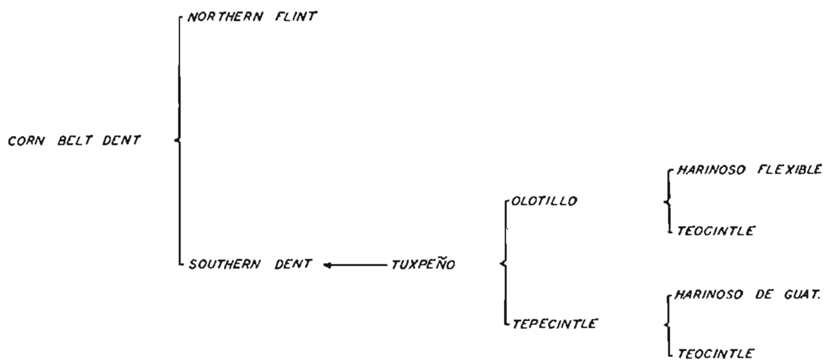


FIG. 132. The probable origin of the Corn Belt dents of the United States.

and Anderson (1948). The Southern Dents in turn are recognized as coming originally from Mexico (Kuleshov, 1929; Mangelsdorf and Reeves, 1939; Brown and Anderson, 1948) and show particular affinities with the cylindrical dent, Tuxpeño, of the east coast of Mexico. Tuxpeño in turn is apparently derived from the hybridization of two races, Olotillo from Chiapas and Tepecintle from Guatemala, both of which were originally flour corns, probably from South America, which have been modified by an introgression of teosinte.

The genealogy of the dent corn of the Corn Belt is therefore approximately as presented in Fig. 132.

Once the corn breeder of the Corn Belt has reached a point of diminishing returns by isolating inbred strains from local varieties he can undoubtedly make further improvement by introducing germplasm from the Southern Dents. The next step is to go back to the original source of this germplasm, the east coast cylindrical dent of Mexico, Tuxpeño. Still later, it may be desirable to utilize germplasm from the separate elements which have made up Tuxpeño, teosinte and the flour corns of Southern Mexico and Guatemala. All of these racial elements have participated in the Corn Belt dent of today, and it is somewhat unlikely that the mixture which has evolved, more or less by accident, is the best which can be produced from the germplasm represented by the separate elements.

Furthermore, there are other races of maize in Mexico, such as Tabloncillo, which have played an important part in the evolution of the modern productive agricultural races of Mexico and which, so far, have had only a minor role, if any, in the development of corn varieties of the United States. The time is ripe for investigating the possibility of utilizing germplasm from such races to modify and improve the corn of the United States or other parts of the world where corn breeding work is in progress or is planned for the future.

It is hoped that the classification presented here will represent a step forward in enabling corn breeders in Mexico, the United States, and other parts of the world to proceed more systematically and less empirically in their breeding operations.

SUMMARY

During the last seven years beginning in the fall of 1943, a systematic collection of the maize varieties from all parts of Mexico has been made. The 2000 varieties now present in this collection were intensively studied with respect to (1) their geographical distribution; (2) vegetative characters of the plant; (3) characters of the tassel; (4) characters of the ear (external and internal); and (5) physiological, genetic and cytological characters. From these studies it has been possible to discern natural relationships between varieties and to group them according to these relationships into races. The classifications made and the evolutionary factors involved are summarized as follows:

1. At least four different factors were involved in bringing about the tremendous diversity of maize in Mexico: (A) Evidence

strongly indicates that the most ancient corn of Mexico was both a pod corn and a pop corn. Whether it originated in Mexico or somewhere else, has not been determined. It undoubtedly at one time was widely distributed in Mexico and from it distinct races of maize developed in different regions. The principal factors involved in the early evolution of this maize probably were the relatively frequent mutations and the partial release from the pressure of natural selection through the intervention of man. (B) Sometime during the history of maize cultivation in Mexico there was in influx of exotic races from countries to the south which hybridized with the indigenous races developed directly from the ancient pod-pop corn. As a result of this hybridization between the exotic and indigenous races and the subsequent introgression of the resulting races one into another, frequently accompanied by hybrid vigor there has been a definite trend toward increased variation and enhanced productiveness. (C) Superimposed upon these two evolutionary mechanisms was the introgression of teosinte germplasm into the races of Mexico and adjacent regions of Guatemala, which introduced new characters and new diversity into the maize of both countries. All of the more productive races of maize in Mexico show evidence of teosinte introgression. (D) The fourth factor in the evolution of maize in Mexico has been the geography of Mexico itself, which with its different kinds of isolating factors both geographical and ecological, is very conducive to the rapid differentiation of cultivated plants.

2. According to their derivation, the races of maize identified up to the present time have been divided into four major groups as follows: Ancient Indigenous, Pre-Columbian Exotic, Prehistoric Mestizos and Modern Incipient.
3. Ancient Indigenous races are those which are believed to have arisen in Mexico from a primitive pod-pop corn which at one time must have been widely distributed. The four races in this group differ from each other by virtue of their independent development in different localities and in different environments, but having descended from a common ancestor without hybridization, they still retain many important characters

in common; namely, pop-corn-type endosperm, small ears, early maturity. All resemble, in some characteristics, the prehistoric corns of South America.

4. Pre-Columbian Exotic races are those believed to have been introduced into Mexico from Central or South America in prehistoric time. The four races recognized as belonging to the group are: Cacahuacintle, Harinoso de Ocho, Olotón, and Maíz Dulce. All have South American counterparts and all except Maíz Dulce have been parents of hybrid races some of which are themselves relatively ancient.
5. Prehistoric Mestizos include races which are believed to have arisen through the hybridization of Ancient Indigenous races with Pre-Columbian Exotic races and through the hybridization of both with a new element, teosinte. Thirteen races of this type are now recognized. Most of them are secondary and even tertiary products of racial hybridization and pedigrees indicating their probable origin are exceedingly complex.
6. Modern Incipient races are races which appear to have developed since the Conquest, and which have not yet reached a state of racial stability. Four races are recognized in this group.
7. Altogether it has been possible to recognize twenty-five distinct and well-defined races of maize in Mexico and four subraces. However, all of the varieties found in Mexico can be by no means assigned to these twenty-nine entities. The majority of the varieties collected are relatively recent mixtures of two or more races. With a continuation of these studies in the future, additional races probably will be identified. Certain races or types which have been recently collected, or on which insufficient data have been accumulated to warrant a classification and genealogy with a reasonable degree of certainty, are included as a group entitled "Poorly Defined Races."
8. The possible value of a classification of maize in relation to its improvement is discussed.

LITERATURE CITED

ANDERSON, E., 1944a. Maíz reventador. Ann. Mo. Bot. Gard. 31: 301–315.

——— 1944b. Homologies of the ear and tassel in *Zea Mays*. Ann. Mo. Bot. Gard. 31: 325–343.

——— 1946a. Maize in Mexico. A preliminary survey. Ann. Mo. Bot. Gard. 33: 147–247.

——— 1946b. Report on maize from Cherán *in* Beals, C., 1946. Cherán: A sierra Tarascan village. Inst. Soc. Anthro., Smithsonian Institute (Wash., D. C.). Publ. 2: 219–223.

——— 1947a. Corn before Columbus. Pioneer Hi-Bred Corn Co., Des Moines, Iowa.

——— 1947b. Field studies of Guatemalan maize. Ann. Mo. Bot. Gard. 34: 433–467.

——— 1949. The corn plant of today. Pioneer Hi-Bred Corn Co., Des Moines, Iowa.

ANDERSON, E., AND BLANCHARD, F. D., 1942. Prehistoric maize from Cañón del Muerto. Amer. Jour. Bot. 29: 832–835.

ANDERSON, E., AND CUTLER, H. C., 1942. Races of *Zea Mays*: I. Their recognition and classification. Ann. Mo. Bot. Gard. 29: 69–89.

ANDERSON, E., AND FINAN, J. J., 1945. Maize in the Yanhuitlán codex. Ann. Mo. Bot. Gard. 32: 361–368.

BAUTISTA, R., Neftalí, 1949. Tipos de maíz en la Mesa Central. Tesis Esc. Nac'l. Agricultura, Chapingo, Mexico. 1–55 (unpublished).

BONAFOUS, M., 1836. Histoire naturelle, agricole et economique du mais. Paris.

BONNETT, O. T., 1948. Ear and tassel development in maize. Ann. Mo. Bot. Gard. 35: 269–287.

BROWN, W. L., AND ANDERSON, E., 1948. The southern dent corns. Ann. Mo. Bot. Gard. 35: 255–268.

CARTER, G. F., AND ANDERSON, E., 1945. A preliminary survey of maize in the southwestern United States. Ann. Mo. Bot. Gard. 32: 297–322.

CHÁVEZ, E., 1913. Cultivo del maíz. Sec. Fom., Dir. Gral. Agricultura, Bol. 74 (Est. Agr. Cent., Mexico).

CUEVAS RÍOS, A., 1947. Tipos de maíz en Chiapas. Tesis Esc. Nac'l. Agricultura, Chapingo, Mexico. 1–35 (unpublished).

CUTLER, H. C., 1946. Races of maize in South America. Bot. Mus. Leaflets, Harv. Univ. 12: 257–291.

CUTLER, H. C., AND CUTLER, M. C., 1948. Studies on the structure of the maize plant. Ann. Mo. Bot. Gard. 35: 301–316.

DE LA ROSA, L., 1846. Memoria sobre el cultivo del maíz en México (México). 1–56.

DEMEREC, M., 1927. Heritable characters of maize XXIX — Midcob color. Jour. Heredity 18: 420–422.

ERDOZAIN, E. R., 1914. Estudio sobre el cultivo del maíz. Imprenta Sec. Fom. Mexico.

GILMORE, M. R., 1931. Vegetal remains of the Ozark bluff-dweller culture. Mich. Acad. Sci. Arts, and Letters 14: 83–102.

HURST, C. T., and ANDERSON, E., 1949. A corn cache from western Colorado. American Antiquity 14: 161–167.
JENKINS, M. T., 1940. The segregation of genes affecting yield of grain in maize. Jour. Amer. Soc. Agron. 32: 55–63.
KELLY, I., AND ANDERSON, E., 1943. Sweet corn in Jalisco. Ann. Mo. Bot. Gard. 30: 405–412.
KEMPTON, J. H., 1924. Jala maize, a giant variety from Mexico. Jour. Heredity 15: 337–344.
KHANKHOJE, P., 1930. Nuevas variedades de maíz. Esc. Nac'l. Agr., Mexico. Bol. Invest. Num. 1.
KIESSELBACH, T. A., 1930. The use of advanced-generation hybrids as parents of double cross seed corn. Jour. Amer. Soc. Agron. 22: 614–626.
KULESHOV, N. N., 1929. The geographical distribution of the varietal diversity of maize in the world. Bul. Appl. Bot., Gen. & Pl. Breeding 20: 506–510.
———1930: The maize of Mexico, Guatemala, Cuba, Panama and Colombia *in* Bukasov, S. M., 1930. — The cultivated plants of Mexico, Guatemala and Colombia. Bul. Appl. Bot., Gen. & Pl. Breeding, Supplement No. 47: 493–501.
LENZ, L. W., 1948. Comparative histology of the female inflorescence of *Zea Mays* L. Ann. Mo. Bot. Gard. 35: 353–376.
LONGLEY, A. E., 1938. Chromosomes of maize from North American Indians. Jour. Agr. Res. 56: 177–195.
LÓPEZ Y PARRA, R., 1908a. El teozinte, origen del maíz. Sec. de Fomento (Mexico). 1–20.
——— 1908b. La buena semilla de maíz. Vázquez e hijos, impresores (México, D. F.). 1–49.
LUMHOLTZ, C., 1902. Unknown Mexico. Charles Scribner's Sons, New York.
MANGELSDORF, P. C., 1947. The origin and evolution of maize. Advances in Genetics 1: 161–207.
——— 1948. The role of pod corn in the origin and evolution of maize. Ann. Mo. Bot. Gard. 35: 377–406.
MANGELSDORF, P. C., AND CAMERON, J. W., 1942. Western Guatemala, a secondary center of origin of cultivated maize varieties. Bot. Mus. Leaflets, Harv. Univ. 10 (8): 217–252.
MANGELSDORF, P. C., AND REEVES, R. G., 1939. The origin of Indian corn and its relatives. Texas Agr. Exp. Sta. Bul. 574.
MANGELSDORF, P. C., AND SMITH, C. E., 1949. New archaeological evidence on evolution in maize. Bot. Mus. Leaflets, Harv. Univ. 13: 213–247.
MEADE, J., 1948. Iziz Centli (El Maíz). Talleres Gráficos de la Nación (México, D. F.) 1–114.
MONTELONGO, E., 1939. Estudio de los tipos de maíz de Chalco. Rev. de Agr. (México).
NEAL, N. P., 1935. The decrease in yielding capacity in advanced generations of hybrid corn. Jour. Amer. Soc. Agron. 27: 666–670.
PÉREZ TORO, A., 1942. La Milpa. Publ. Gob. Yuc., Mérida, Yucatán (México). 1–56.
RAMÍREZ, JOSÉ, 1903. Tres mazorcas anómales. La Naturaleza, 2a Serie, 3: 377–381, (México).

Reeves, R. G., 1944. Chromosome knobs in relation to the origin of maize. Genetics 29: 141–147.

Richey, F. D., Stringfield, G. H., and Sprague, G. F., 1934. The loss in yield that may be expected from planting second generation double-crossed seed corn. Jour. Amer. Soc. Agron. 26: 196–199.

Sahagún, Fr. B. de, 1529–1590. Historia general de las cosas de Nueva España. Editorial P. Robredo, México, D. F. (Pub. in 1938).

Siméon, R., 1885. Dictionaire de la Langue Nahuatl. Imprimerie Nationale, Paris.

Souza Novelo, N., 1948. "El Maíz" La Milpa. Inst. Tec. Agr. Henequenero, Mérida, Yucatán (México). 1–32.

Sprague, G. F., and Jenkins, M. T., 1943. A comparison of synthetic varieties, multiple crosses, and double crosses in corn. Jour. Amer. Soc. Agron. 35: 137–147.

Sturtevant, E. L., 1899. Varieties of corn. U.S. Dept. Agric. Off. Exp. Sta. Bul. 57.

Wallace, H. A., and Bressman, E. N., 1928. Corn and corn growing. John Wiley and Sons (New York).

Wellhausen, E. J., 1947. Comparación de variedades del maíz obtenidas en el Bajío, Jalisco y la Mesa Central. Folleto Técnico No. 1. O.E.E., S.A.G. (México, D. F.).

Wellhausen, E. J., and Roberts, L. M., 1949. Methods used and results obtained in corn improvement in Mexico. Iowa Agr. Exp. Sta. Res. Bul. 371: 525–537.

West, R. C., 1948. Cultural geography of the modern Tarascan area. Inst. Soc. Anthro., Smithsonian Inst., Publ. No. 7.

Wright, S., 1922. The effects of inbreeding and cross breeding on guinea pigs. U.S. Dept. Agric. Bul. 1121.

APPENDIX

TABLE 13. Races of Maize of Mexico Compared in Characters of the Plants.

Races	No.* Collections Studied	Altitude ** meters	Plant height meters	Leaves				
				Total No.	No. Above Ear	Width cm.	Length cm.	Venation Index
A. Ancient Indigenous								
1. Palomero Toluqueño	2	2200–2800	1.7	12.2	4.0	6.5	66.0	2.81
2. Arrocillo Amarillo	2	1600–2000	—	—	—	—	—	—
3. Chapalote	1	100–600	1.6	12.8	4.6	7.6	80.5	2.62
4. Nal-Tel	1	100	1.3	12.0	4.3	8.7	65.6	3.03
B. Pre-Columbian Exotic								
5. Cacahuacintle	1	2200–2800	1.8	12.8	4.2	8.2	81.5	3.16
6. Harinoso de Ocho	1	100	1.6	12.1	4.3	8.6	84.3	2.56
Sub-race Elotes Occidentales	5	0–1500	2.0	14.3	4.9	8.7	89.5	3.24
7. Olotón	2	2000–2400	2.5	16.0	—	9.0	—	2.89
8. Maíz Dulce	1	1000–1500	2.0	13.2	4.2	8.0	80.0	3.46
C. Prehistoric Mestizos								
9. Cónico	12	2200–2800	1.7	11.2	3.5	8.2	72.0	2.78
10. Reventador	2	0–1500	1.5	11.0	4.9	7.1	75.7	3.33
11. Tabloncillo	7	0–1500	2.4	14.6	5.0	8.6	79.8	3.56
Sub-race Perla	3	0–1000	1.5	10.4	4.1	7.7	61.8	3.23
12. Tehua	6	600–1000	3.3	20.5	—	8.7	—	3.22
13. Tepecintle	3	0–600	1.8	13.6	5.6	10.0	85.7	2.88
14. Comiteco	5	1100–1500	3.1	20.0	—	10.5	—	2.79
15. Jala	3	1000	3.1	14.4	5.0	7.8	82.3	2.94
16. Zapalote Chico	7	100	1.2	10.0	4.0	7.9	64.2	3.30
17. Zapalote Grande	2	100–600	1.6	15.9	5.4	9.6	81.4	2.92
18. Pepitilla	3	1000–1700	2.7	14.9	5.1	8.4	85.0	2.78
19. Olotillo	6	300–700	2.9	20.0	—	10.5	—	3.23
20. Tuxpeño	5	0–500	2.7	18.0	6.0	10.5	95.0	3.11
21. Vandeño	7	0–500	2.5	13.7	5.1	9.5	93.3	3.00
D. Modern Incipient								
22. Chalqueño	8	1800–2300	2.3	14.7	4.6	9.7	84.1	2.93
23. Celaya	9	1200–1800	2.5	16.0	4.9	8.9	82.3	2.84
24. Cónico Norteño	24	1600–2100	2.0	12.8	4.2	7.9	74.6	2.93
25. Bolita	5	900–1500	2.0	13.5	4.8	9.2	77.8	3.14

* A list of the collections selected to represent each race is given in Table 18.
** Altitude at which the race is commonly found.

TABLE 14. Races of Maize of Mexico Compared in Characters of the Tassels.

	Length cm.		*Branching Space*		*Branches*			
Races	*Tassel*	*Peduncle*	*Length cm.*	*Percent*	*No.*	*% Secondary*	*% Tertiary*	*Condensation Index*
A. Ancient Indigenous								
1. Palomero Toluqueño	33.4	6.8	3.4	10	3.6	2.8	0.0	2.52
2. Arrocillo Amarillo *	—	—	—	—	—	—	—	—
3. Chapalote	35.8	6.0	9.2	26	13.0	16.0	0.0	1.20
4. Nal-Tel	32.7	3.2	11.8	30	22.8	30.0	0.4	1.00
B. Pre-Columbian Exotic								
5. Cacahuacintle	36.8	6.2	4.9	14	5.6	8.0	0.9	1.60
6. Harinoso de Ocho	41.9	4.2	11.2	25	10.0	12.0	0.0	1.05
Sub-race Elotes Occidentales	39.2	7.3	8.2	20	8.8	9.5	0.0	1.07
7. Olotón	46.8	—	13.0	28	16.8	23.5	0.0	1.27
8. Maíz Dulce	44.0	4.0	11.6	25	18.1	15.4	0.0	1.67
C. Prehistoric Mestizos								
9. Cónico	34.5	6.5	4.5	14	5.5	7.0	0.0	2.58
10. Reventador	40.7	1.9	7.6	19	8.4	5.9	0.0	1.15
11. Tabloncillo	40.0	7.2	9.0	23	8.8	11.5	0.0	1.10
Sub-race Perla	37.0	9.1	12.4	32	13.2	13.0	0.0	1.04
12. Tehua	43.0	—	16.9	40	27.7	21.1	0.1	1.33
13. Tepecintle	41.5	4.1	14.4	34	24.7	21.5	1.3	1.08
14. Comiteco	39.6	—	13.7	35	21.3	18.3	0.0	1.22
15. Jala	39.5	4.9	11.1	35	17.9	12.3	0.0	—
16. Zapalote Chico	34.0	6.5	10.7	34	18.9	16.0	0.0	1.72
17. Zapalote Grande	39.7	3.4	13.0	30	23.9	12.6	0.0	1.55
18. Pepitilla	38.6	3.2	11.7	35	21.8	10.9	0.0	1.47
19. Olotillo	39.2	5.2	17.6	45	30.3	34.0	2.3	1.01
20. Tuxpeño	42.6	5.1	14.4	30	22.9	20.5	0.7	1.55
21. Vandeño	40.5	6.0	12.5	33	20.8	18.2	1.4	1.21
D. Modern Incipient								
22. Chalqueño	43.0	1.8	7.9	19	10.7	10.1	0.0	2.55
23. Celaya	42.4	4.8	12.6	28	21.1	16.8	0.2	1.10
24. Cónico Norteño	40.3	5.9	10.2	25	17.5	18.3	0.0	1.38
25. Bolita	40.4	7.1	11.7	29	17.4	19.0	0.1	1.27

* Not yet studied.

TABLE 15. Races of Maize of Mexico Compared in External Characters of the Ears.

Races	Length cm.	Diam. cm.	Row No.	Shank Diam. mm.	Average Shank Length cm.	Average No. Husks	Kernel Characters: Width mm.	Thickness mm.	Length mm.	Denting	Striations
A. Ancient Indigenous											
1. Palomero Toluqueño	10.2	3.4	23.0	8.2	7.4	8.2	4.7	2.8	11.4	0.0°	0.5
2. Arrocillo Amarillo	9.8	2.7	15.4	8.3	17.5	10.8	5.5	2.5	8.8	0.1	0.5
3. Chapalote	11.0	2.9	12.3	9.7	7.0	7.8	6.7	4.1	7.2	0.0	1.6
4. Nal-Tel	7.9	2.7	11.4	7.1	7.1	11.4	6.7	3.9	7.4	0.1	1.0
B. Pre-Columbian Exotic											
5. Cacahuacintle	14.5	4.7	15.2	10.2	7.3	7.4	9.8	5.2	14.0	0.0	0.2
6. Harinoso de Ocho	19.1	3.8	8.0	14.0	18.3	8.8	12.0	4.4	11.2	0.0	1.0
Sub-race Elotes Occidentales	17.1	4.0	9.9	11.7	10.4	7.6	10.7	4.5	—	0.4	1.3
7. Olotón	18.3	4.3	11.7	17.7	—	—	9.7	6.0	11.2	0.0	0.4
8. Maíz Dulce	13.7	4.5	14.5	11.3	13.3	11.6	8.5	4.0	12.3	1.5°°	°°°
C. Prehistoric Mestizos											
9. Cónico	13.6	4.3	16.0	8.8	10.6	7.6	6.6	3.6	14.8	1.3	0.0
10. Reventador	16.5	3.2	11.9	8.8	5.1	7.8	7.4	3.6	7.3	0.0	2.0
11. Tabloncillo	16.4	4.1	9.1	11.0	15.3	9.2	11.5	4.3	10.3	1.7	1.2
Sub-race Perla	17.0	3.7	8.3	10.7	7.9	7.6	11.3	4.2	—	0.2	1.7
12. Tehua	19.1	5.7	17.0	21.5	10.0	14.0	9.1	3.9	11.6	1.0	0.2
13. Tepecintle	10.4	4.9	11.8	10.8	6.0	14.6	9.1	3.7	11.9	1.7	0.3
14. Comiteco	28.7	5.2	13.5	22.6	14.9	10.6	9.5	4.5	13.7	0.5	0.1
15. Jala	30.5	5.9	14.7	34.5	9.0	15.6	10.9	4.6	14.2	2.0	0.2
16. Zapalote Chico	9.9	4.2	10.7	13.7	6.0	13.4	9.8	3.6	10.1	2.0	0.0
17. Zapalote Grande	14.8	4.9	15.7	18.1	5.3	18.2	9.3	3.8	11.1	2.0	0.0
18. Pepitilla	12.3	5.3	15.5	12.0	13.6	14.6	7.9	3.5	20.8	0.8°	0.0
19. Olotillo	19.8	3.8	9.4	10.5	9.0	10.8	10.8	3.9	11.7	1.8	0.2
20. Tuxpeño	19.7	4.4	12.6	13.4	9.3	15.6	9.3	3.7	12.8	2.0	0.1
21. Vandeño	17.2	5.1	13.2	13.0	8.4	12.4	9.1	3.6	13.9	1.8	0.2
D. Modern Incipient											
22. Chalqueño	16.0	4.9	16.6	10.1	14.7	7.2	7.2	3.9	15.4	1.8°	0.0
23. Celaya	17.0	4.5	12.4	9.9	12.1	11.8	9.1	3.9	12.9	1.7	0.3
24. Cónico Norteño	13.1	4.6	16.0	11.3	10.6	7.4	7.3	3.5	14.9	1.8	0.1
25. Bolita	11.6	4.2	10.2	9.8	9.9	8.6	10.4	4.1	12.3	1.8	0.2

° Pointed.
°° Wrinkled.
°°° Unknown due to wrinkling.

TABLE 16. Races of Maize of Mexico Compared in Internal Characters of the Ears.*

	Diameter mm.			*Length mm.*		*Indices*						
Races	*Ear*	*Cob*	*Rachis*	*Kernel*	*Rachilla*	*Cob/ Rachis*	*Glume/ Kernel*	*Rachilla/ Kernel*	*Pedicel Hairs*	*Rachis Flap*	*Rachis Induration*	*Teosinte Intro-gression*
A. Ancient Indigenous												
1. Palomero Toluqueño	34.0	19.5	10.4	11.4	0.4	1.88	.40	.04	0	0	0	0
2. Arrocillo Amarillo	26.6	15.6	8.4	8.8	0.3	1.86	.41	.03	0–1	0	0–1	1
3. Chapalote	29.2	22.0	11.2	7.2	1.8	1.96	.75	.25	0	3	0–1	1
4. Nal-Tel	27.2	19.2	9.2	7.4	1.6	2.09	.68	.22	0	2–3	1	0–1
B. Pre-Columbian Exotic												
5. Cacahuacintle	47.0	27.7	11.7	14.0	3.6	2.37	.57	.26	4	3	0–1	0
6. Harinoso de Ocho	38.3	21.7	10.7	11.2	2.6	2.03	.49	.23	3	2–3	1	2
7. Olotón	42.7	27.7	14.3	11.2	3.0	1.94	.60	.27	2–3	1–3	1	2
8. Maíz Dulce	46.0	26.3	15.7	12.3	2.8	1.68	.43	.23	0	2	1	2–3
C. Prehistoric Mestizos												
9. Cónico	42.4	19.0	9.6	14.8	1.6	1.98	.32	.11	2–4	2–3	0	0
10. Reventador	28.4	19.6	9.8	7.3	2.0	2.00	.67	.28	0–3	1	1	2–3
11. Tabloncillo	37.4	23.4	12.5	10.3	2.1	1.87	.53	.20	0–4	2–3	2	2–3
12. Tehua	56.5	42.0	27.5	11.6	2.9	1.53	.63	.25	3–4	1–2	1	2
13. Tepecintle	51.0	32.8	20.5	11.9	3.3	1.60	.52	.28	0	1–3	1–2	4
14. Comiteco	52.5	34.5	18.5	13.7	3.3	1.86	.58	.24	2–3	3	1	2
15. Jala	55.0	28.0	18.0	14.2	4.3	1.56	.35	.30	2–3	3	2	3
16. Zapalote Chico	41.7	23.3	14.0	10.1	3.7	1.66	.46	.37	0–1	1	1–2	3
17. Zapalote Grande	46.8	31.5	19.2	11.1	2.7	1.64	.55	.24	1–2	1	1–2	2–3
18. Pepitilla	55.0	25.0	12.5	20.8	0.4	2.00	.30	.02	0–3	1–3	1	1–2
19. Olotillo	37.7	22.7	9.7	11.7	2.3	2.34	.56	.20	0–3	1	1	3
20. Tuxpeño	46.5	26.5	16.5	12.8	2.2	1.61	.39	.17	0–4	1	1	3
21. Vandeño	53.0	32.3	19.0	13.9	3.1	1.70	.48	.22	0–3	1	1	3
D. Modern Incipient												
22. Chalqueño	51.3	28.3	15.0	15.4	2.7	1.89	.43	.18	4	2	1	2
23. Celaya	44.3	23.3	13.7	12.9	2.4	1.70	.37	.19	1–3	2–3	1–2	2–3
24. Cónico Norteño	46.3	23.3	14.0	14.9	1.2	1.66	.31	.10	0–3	1	1	2
25. Bolita	45.3	26.7	15.7	12.3	2.5	1.70	.45	.20	3	2–3	1	2

* Figures presented in the table are based on an average of the measurements or scores from 3 to 5 typical ears.

TABLE 17. Races of Maize of Mexico Compared in Physiological, Genetic, and Cytological Characters.

Races	Maturity	Rust	Pilosity	Color		Chromosome Knobs		
				Sheath	% Mid-cob	No. Plants Studied	Range	Average
A. Ancient Indigenous								
1. Palomero Toluqueño	90	1	4–5	4–5	0	6	0–4	1.2
2. Arrocillo Amarillo	—	—	—	—	—	—	—	—
3. Chapalote	110	3	0–1	0–1	50	3	—	6.0
4. Nal-Tel	105	4	1	1	0	2	4–7	5.5
B. Pre-Columbian Exotic								
5. Cacahuacintle	93	1	5	5	—	1	—	3.0
6. Harinoso de Ocho	—	1	0	0	0	—	—	—
Sub-race Elotes Occidentales	100	2–3	1	1	32	2	8–9	8.5
7. Olotón	108	1	2–3	1–2	—	1	—	5.0
8. Maíz Dulce	105	3	1	1–2	50	1	—	5.0
C. Prehistoric Mestizos								
9. Cónico	90	1	3–4	4–5	39	3	—	1.0
10. Reventador	106	1–2	1	0	50	4	5–10	8.0
11. Tabloncillo	107	1–2	1	0–1	54	3	5–9	7.6
Sub-race Perla	97	3	1	1	10	3	6–8	7.5
12. Tehua	169	2	1	0–1	45	2	6–8	7.0
13. Tepecintle	113	4	1	2	42	3	6–11	9.0
14. Comiteco	137	1–2	1	1–2	4	9	3–8	5.6
15. Jala	134	2	1	0	—	2	7–8	7.5
16. Zapalote Chico	96	4–5	0–1	2	18	6	10–14	11.7
17. Zapalote Grande	118	3–4	1	1–2	0	5	6–9	7.4
18. Pepitilla	122	2–3	1	0	3	3	7–10	8.5
19. Olotillo	135	2–3	1	1	0	12	5–9	6.3
20. Tuxpeño	148	3	1	1–2	58	5	6–7	6.1
21. Vandeño	125	3–4	1	2–3	29	9	6–11	8.1
D. Modern Incipient								
22. Chalqueño	107	1	2–3	2–3	30	4	6–7	6.8
23. Celaya	116	1–2	1	0–1	67	5	8–10	8.5
24. Cónico Norteño	98	1–2	1–2	1	56	2	—	8.0
25. Bolita	98	2	1	1	40	4	7–11	8.6

TABLE 18. — List of collections studied as representative of each race of Mexican maize.

Race of Corn	*Accession Number of Collection* *
A. Ancient Indigenous Races	
1. Palomero Toluqueño	Mex. 5, Mex. 6.
2. Arrocillo Amarillo	Pue. 91, 92.
3. Chapalote	Sin. 2.
4. Nal-Tel	Yuc. 7.
B. Pre-Columbian Exotic Races	
5. Cacahuacintle	Mex. 7.
6. Harinoso de Ocho	Nay. 24.
Sub-race Elotes Occidentales	Nay. 29, 38; Jal. 71, 54, 77.
7. Olotón	Guat. 45, 15.
8. Maíz Dulce	Jal. 78.
C. Prehistoric Mestizo Races	
9. Cónico	Mex. 3, 23, 58, 72; Pue. 32, 48, 54, 68, 70, 108, 109, 116.
10. Reventador	Nay. 15, 39.
11. Tabloncillo	Jal. 42, 63, 43, 87, 100, 102, 103.
Sub-race Perla	Nay. 12, 16, 41.
12. Tehua	Chis. 29, 159, 160, 161, 204, 215.
13. Tepecintle	Chis. 26, 76, 225.
14. Comiteco	Chis. 38, 39, 86, 94, 140.
15. Jala	Nay. 6; Jal. 44, 69.
16. Zapalote Chico	Oax. 48, 52, 54, 56, 50, 51, 70.
17. Zapalote Grande	Chis. 104, 224.
18. Pepitilla	Mor. 17; Gro. 2, 3.
19. Olotillo	Chis. 52, 53, 56, 59, 81, 90.
20. Tuxpeño	Ver. 39, 44; Pue. 27, 42; Oax. 9.
21. Vandeño	Chis. 25, 30, 31, 112, 114; Gro. 96, 124.
D. Modern Incipient Races	
22. Chalqueño	Mex. 35, 37, 48; Pue. 82, 87, 101; Zac. 4; Hgo. 7.
23. Celaya	Gto. 20, 28, 29, 36, 69, 75, 77, 84, 88.
24. Cónico Norteño	Gto. 16, 19, 21, 22, 23, 34, 42, 49, 50, 56, 60, 68, 70, 73; Ags. 7, 8, 14, 15; Zac. 12; Qro. 1-5.
25. Bolita	Oax. 28, 33, 40, 44, 68.

* Accession numbers used in the corn collection of the Rockefeller Foundation.

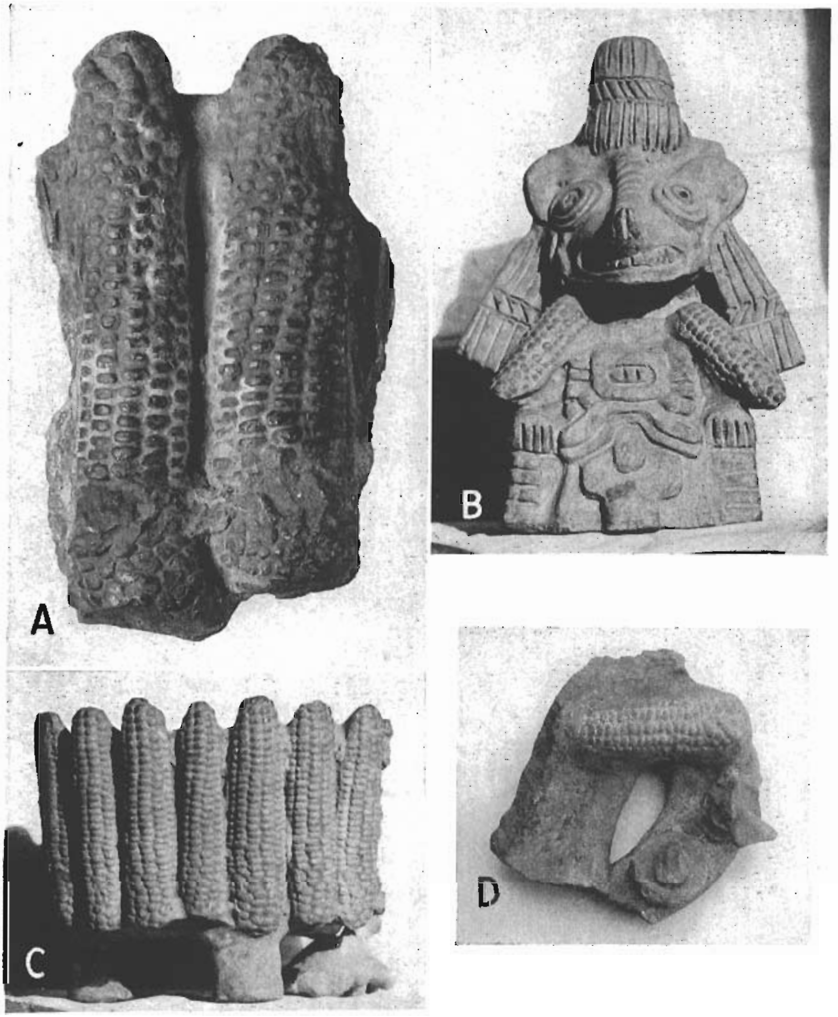


PLATE I

A. Two ears of maize from the headdress of a Mexican funerary urn. (Courtesy American Museum of Natural History, New York.)

B. The Zapotec "God of Rain" decorated with ears of maize made by means of moulds of actual ears. This idol has been classified as Monte Albán 4 which dates it at approximately 800–1000 A.D.

C. A Zapotec funeral urn with ears of corn approaching those of the ancient race Olotillo. These, like those in B, were made from moulds of actual ears.

D. This archaeological specimen collected in Guatemala shows an ear almost identical with those of the primitive race Nal-Tel which still exists to a limited extent in parts of Southern Mexico especially in the Yucatán Peninsula. The photograph was kindly furnished by Dr. A. V. Kidder of the Carnegie Institution of Washington and has been described in "Notes on Middle American Archaeology and Ethnology" No. 92 Carnegie Institution of Washington, Cambridge, 1949.

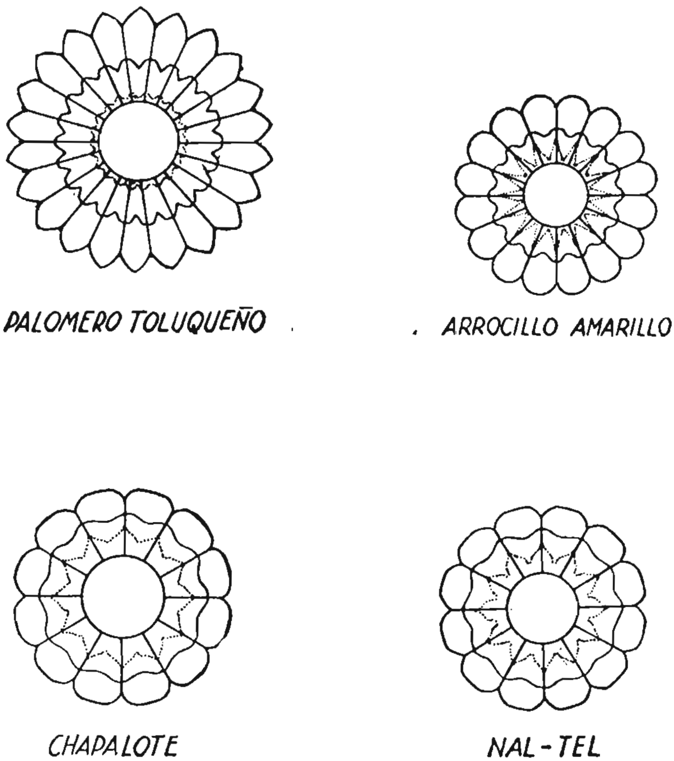


PLATE II. Ear cross-section diagrams of the four Ancient Indigenous races.

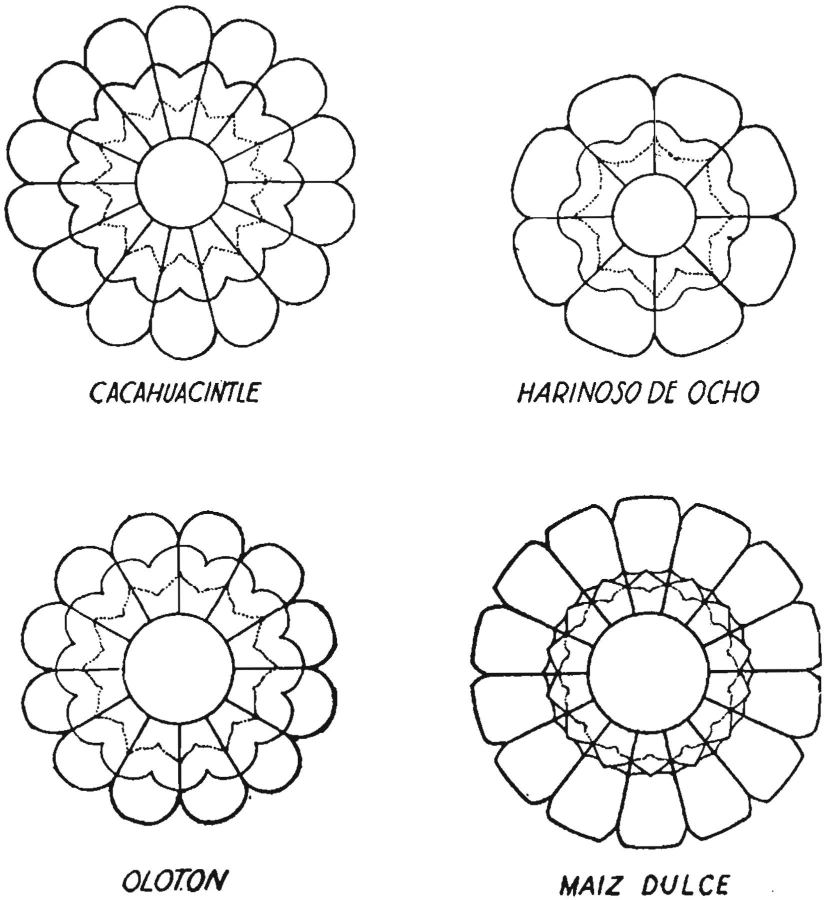


PLATE III. Ear cross-section diagrams of the four Pre-Columbian Exotic races.

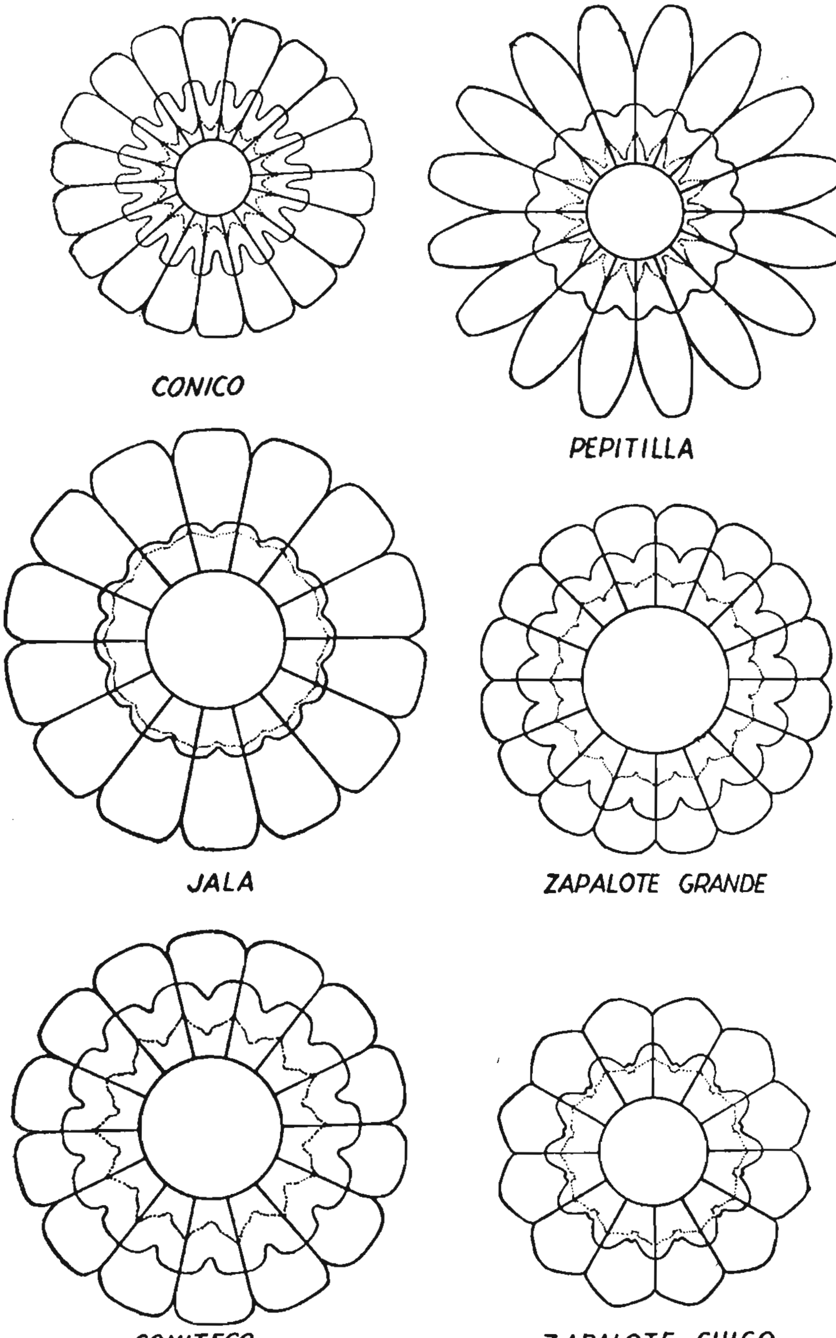
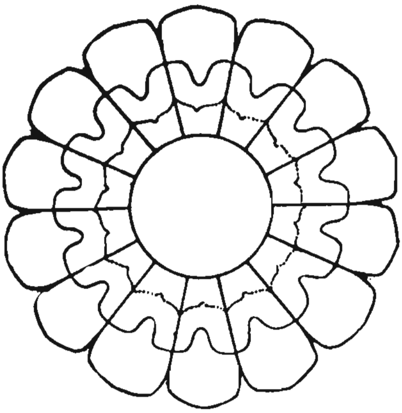
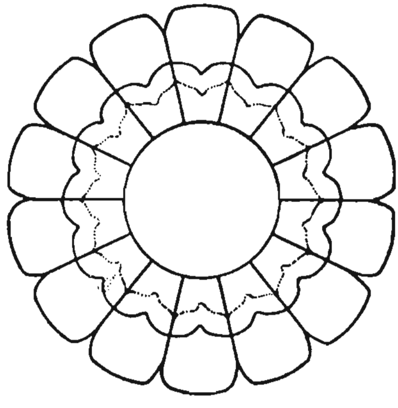


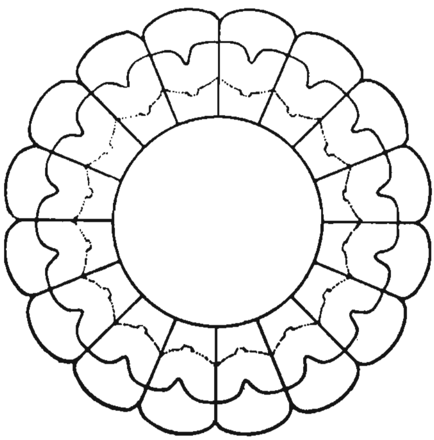
PLATE IV. Ear cross-section diagrams of six of the thirteen races classified as Prehistoric Mestizos.



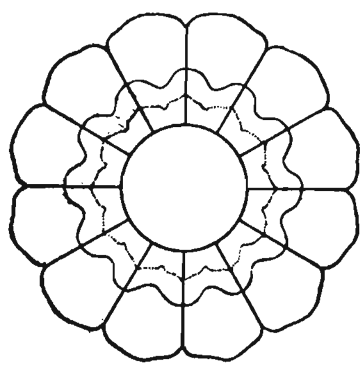
VANDEÑO



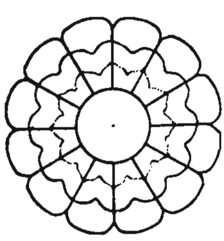
TEPECINTLE



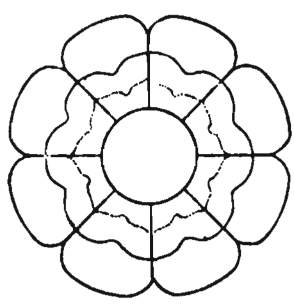
TEHUA



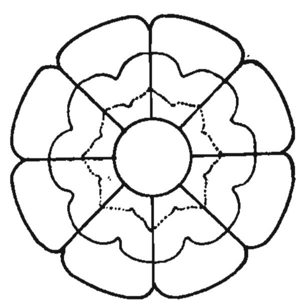
TUXPEÑO



REVENTADOR



TABLONCILLO



OLOTILLO

PLATE V. Ear cross-section diagrams of seven of the thirteen races classified as Prehistoric Mestizos.

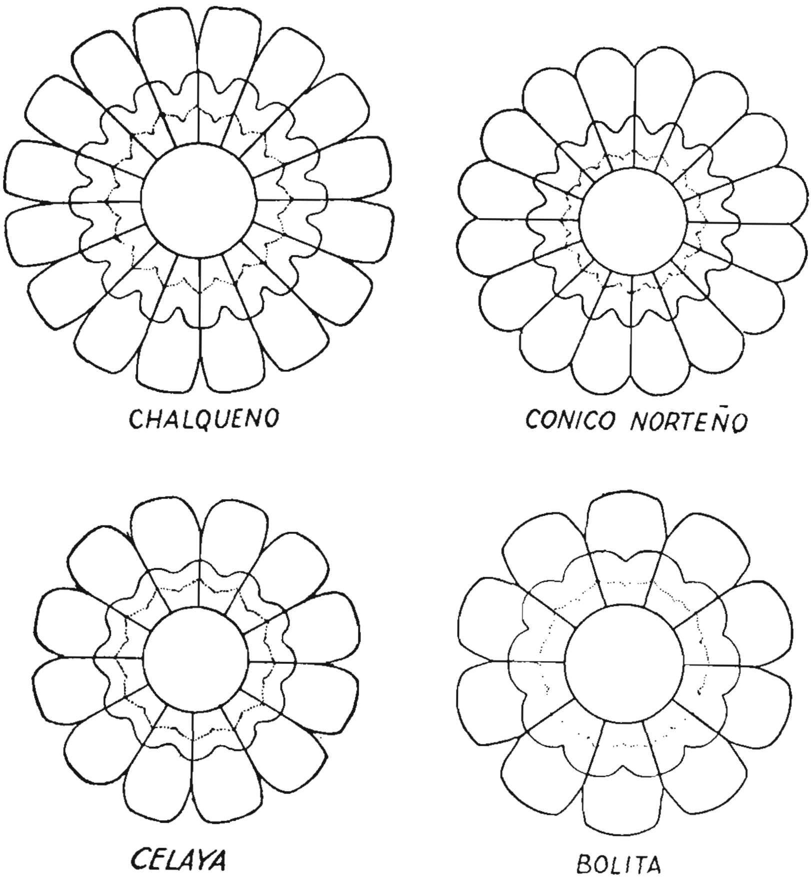


PLATE VI. Ear cross-section diagrams of the four races classified as Modern Incipient.

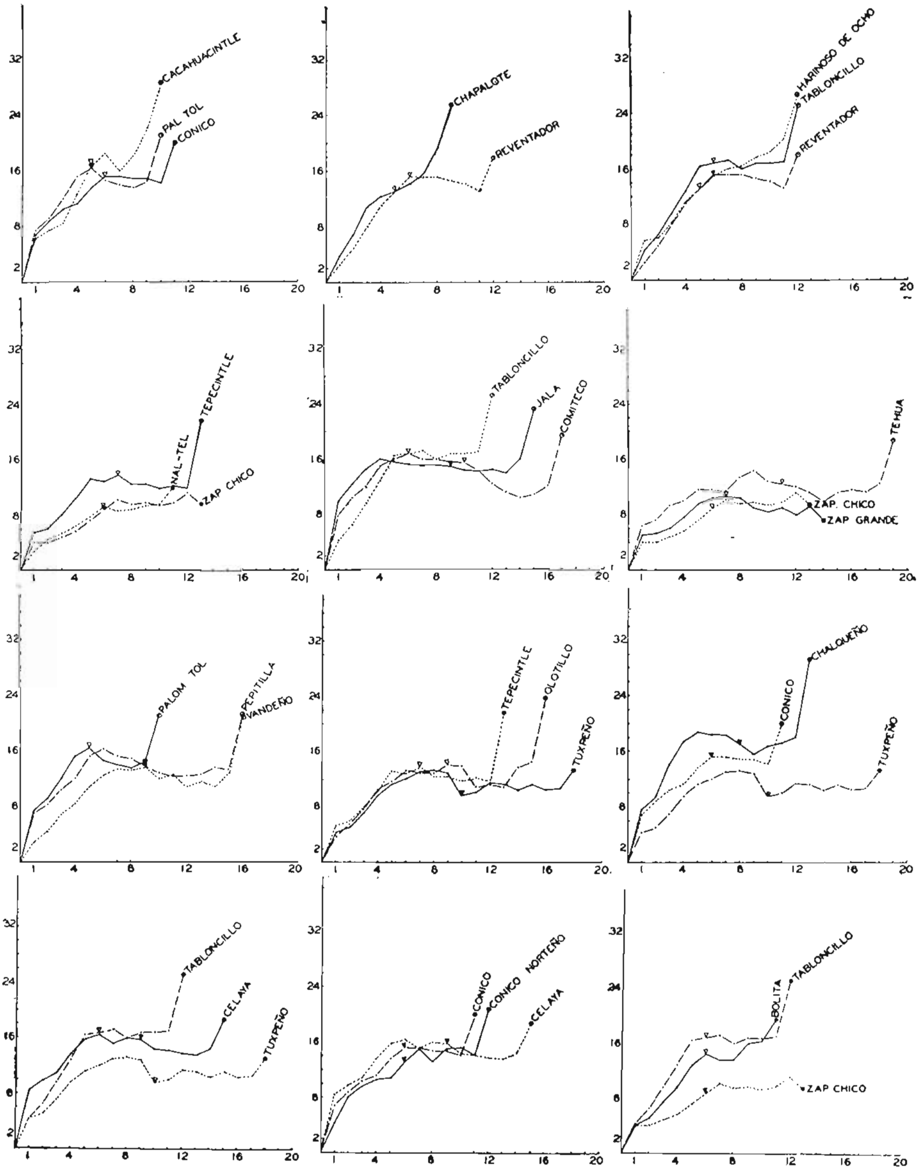


PLATE VII. Internode patterns. Vertical axis represents length of internodes in centimeters. Horizontal axis represents number of nodes.