2007

Characterization and classification of Native American maize landraces from the Southwestern United States

Lindsay C. Werth
Iowa State University

Characterization and classification of Native American maize landraces from the Southwestern United States

by

Lindsay C. Werth

a thesis submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Co-majors: Sustainable Agriculture; Crop Production and Physiology

Program of Study Committee:
Candice Gardner, Co-major Professor
Allen Knapp, Co-major Professor
Ted Bailey

Iowa State University

Ames, Iowa

2007

DEDICATION

This project is dedicated in memory of Deb Muenchrath. She provided the inspiration, drive and enthusiasm to get this project started and the motivation to finish it. I am immensely grateful for her trust and faith in my abilities and her ever present joy and excitement.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGMENTS

Seeds stocks for this study were provided by the North Central Regional Plant Introduction Station in Ames, Iowa, through maize curator Mark Millard, and from Deb Muenchrath at Iowa State University. Help with statistical analysis was provided by Ted Bailey, Philip Dixon and Anna Petersen. Funding for this project was received through a cooperative agreement with the USDA-ARS.

This project could not have been completed without the help of many people. Fieldwork, data and sample collection in Ames was done by Candice Gardner, Larry Lockhart, Mark Millard, Mark Von Cruz and Maria Erickson. At the New Mexico location, much help was received from the staff at the research station, especially Mick O'Neill, Curtis Owen, Kenneth Kohler, Tom Jim, Merlin Begay, Margaret West and Robert Heyduck. Many students helped with data collection in the field including Sandra Brown-Polacca, Jamie Beam, Leandra Jones, Holly Akins, Linda Jones, Iris Garnanez, Carleen Simpson, Nikki Pryor, Charlene Begay, Kyle O'Neill, Colby Hamilton and Max Labato. The staff at the Plant Introduction Station in Ames provided much equipment and assistance in data collection. Several students assisted with data collection in the lab, including Erik Olson, Ben Johansen and Nicki Pawlak. Harvesting was done with the help of Karen Adams, Carolyn Lawrence, Ana Gulbani, Jean Muenchrath, Ryan Petersen, Candice Gardner and Gail Werth. Help with the NIR grain analysis was provided by Susan Duvick, with destructive grain analysis for compositional traits done by the ISU Grain Quality Laboratory.

I am very grateful for the assistance of my current committee members Candice Gardner, Allen Knapp and Ted Bailey, and to my past major professors Deb Muenchrath and Ricardo Salvador. All these people provided assistance at different stages in my project. I am also grateful for the help and enthusiasm of Karen Adams.

So many people have stepped in to help me during the completion of this project. I am grateful to the Agronomy Department and the many professors who offered assistance and understanding to me throughout my research. It could not have been accomplished without their support.

ABSTRACT

The importance and diversity of maize in the Southwestern United States, and questions about their relationships to environmental and cultural factors, drove the need to characterize and classify known existing landraces. Maize landraces and human cultures have co-evolved, with maize being shaped by diverse environmental and cultural selection pressures. Understanding maize diversity, and relationships between maize landraces can lead to insights into the cultural history of the Southwest and the effect of diverse environmental stress on maize diversity development and utilization. This study examined 134 landraces from the Southwest, 13 landraces from Mexico and 12 Midwestern controls. Fields were located in Farmington, New Mexico and Ames, Iowa. Measurements were taken on phenological, vegetative and reproductive characteristics. Significant differences among accessions, environments and ethnic groups were found. There was also a significant ethnic group by environment interaction. Analysis of the accession by environment interaction, by ethnic group, indicated that several ethnic groups had more variables with significant accession by environment interaction. Principal component and cluster analyses showed a continuum of landraces, with the Pueblo and southern Arizona landraces on the extreme ends and many intermediates. One group of landraces grouped separately, and included Hopi and Tohono O'odham landraces with large ears. This group also included Mexican June, which may reflect the effects of introductions of dent maize into the Southwest. Five primary clusters were identified by the cluster analysis and include a Pueblo cluster, a Pima and Tohono O'odham cluster, an intermediate cluster, a cluster of cornbelt dents and a cluster with large-eared Hopi and Tohono O'odham landraces. The cluster relationships correlate well with language groups and geographic and climatic factors. It is difficult to distinguish the effect of cultural factors, such as geographic isolation and the introduction and spread of Spanish cultural influences, on the relationships seen in the clustering. The racial distinctions found in previous studies of *Pima-Papago* and *Pueblo* are confirmed by this study, with minor differences. Relationships with Mexican landraces and Midwestern maize were also examined and can provide insight into maize migration into the Southwest and the effect of introductions of commercial maize on traditional maize landraces.

INTRODUCTION

Understanding the diversity of, and relationships between, maize landraces in the Southwestern United States can lead to insights into the cultural history of the Southwest and the effect of diverse environmental stresses on the development and utilization of maize diversity. Maize evolution is affected by the interactions of environmental and cultural selection pressures, isolation and migration (Harlan, 1975). The presence of these factors in the Southwest contributes to the morphological diversity found in current landraces from the area.

Maize was domesticated approximately nine thousand years ago in Mexico and has been cultivated in the Southwest for at least three thousand years (Adams et al., 2006). As a result of migration of maize northward out of Central Mexico into the Southwest, new environmental selection pressures were introduced. The Southwest is agriculturally isolated by both geography and climate and is characterized by many localized climatic conditions (Carter and Anderson, 1945). The combination of isolation and diverse environmental selection pressures has led to a range of phenotypic diversity adapted to the specific environmental conditions of the Southwest.

The Southwest contains a wide range of Native American cultures and languages (Jorgensen, 1983). Maize landraces and human cultures have co-evolved in the Southwest because of the dependence of maize on humans for survival and the influence of maize on human populations (Muenchrath et al., 1995). Cultural selection pressures impacted ear morphology in particular, because of the use of ears for human consumption (Weatherwax, 1954). Maize also has a spiritual importance. Ford (1994, p. 525) has noted that "Corn as a material object and an idea pervades every aspect of Pueblo life from birth to death and from past to future." Conscious and unconscious cultural selection pressures helped to create a diversity of landraces that satisfied both subsistence and spiritual needs.

Classification tools are used to better understand the relationships between various landraces. Maize classification was first attempted by Sturtevant in the late 1800's using kernel endosperm type (Sturtevant, 1880). Later classifications used a wide range of vegetative and reproductive characteristics and employed numerical taxonomic techniques. Many studies have focused on maize from Central and South America. However, there have

only been a few studies conducted on Southwestern maize and they do not represent a comprehensive view of the diversity of present maize landraces. Adams et al. (2006) noted that there is still a lack of comparative, descriptive maize baseline data in the United States, especially data on maize landraces grown under identical and well-documented environmental conditions. This deficiency highlights the need for a comprehensive study of Southwestern maize landraces conducted in their area of adaptation. In addition, there has not been a comprehensive attempt to compare maize classification to cultural and environmental factors.

One goal of classification is to group landraces into races. Harlan (1975, p. 130) offered the following definition of landrace. "Landraces have a certain genetic integrity. They are recognizable morphologically; farmers have names for them and different landraces are understood to differ in adaptation to soil type, time of seeding, date of maturity, height, nutritive value, use and other properties. Most important, they are genetically diverse." Zeven (1998) has also recognized that landraces often have high yield stability and intermediate yield in low input agricultural systems. Races are composed of landraces with similar characteristics. The most commonly cited definition of race was given by Anderson and Cutler in 1942. Racial definitions are flexible because of the difficulty of assigning races to maize. There are often extremes of diversity with many intermediates. However, racial designation is still an important method of understanding relationships between groups of landraces. In the Southwest two primary races have been identified in previous studies, the *Pima-Papago* and the *Pueblo* (Anderson and Cutler, 1942, Anderson, 1945, Carter and Anderson, 1945).

Maize landraces in the Southwest represent a diverse set of germplasm. Since the introduction of hybrid maize there has been a loss of diversity in maize germplasm. Lack of variability diminishes the ability of breeders to select variants in response to changes in consumer preferences, new or evolving disease and pest pressures, and changing cultural practices (Goodman, 1990). The availability of germplasm is especially important since industry relies primarily on germplasm from two races, the northern flints and the southern dents. This narrow genetic base makes commercial germplasm vulnerable to new stresses (Committee on genetic vulnerability of major crops, 1972). For existing maize germplasm to

be utilized to mitigate the impact of these risks, it is also necessary for it to be characterized (Goodman, 1990).

Maize landraces can also play a role in the sustainable agriculture movement. Sustainable agriculture has been defined in many ways. The Leopold Center for Sustainable Agriculture summarizes these definitions by saying that, "In general, sustainable agriculture addresses the ecological, economic and social aspects of agriculture. To be sustainable, agriculture can operate only when the environment, its caretakers and surrounding communities are healthy." Sustainable agriculture must also be able to persist over many generations. Landraces can be utilized in local agricultural systems that are focused on this long-term stability and diversity (Cleveland et al., 1994). Diversity within species is recognized as an important factor in yield stability, which is an important element in traditional agricultural systems with low inputs (Cleveland et al., 1994). The diverse germplasm of maize landraces could be used in the development and maintenance of smaller, traditional agricultural systems in the Southwest.

OBJECTIVES

The primary goal of this project is to characterize and classify the Southwestern maize landraces that are currently held in the National Plant Germplasm System. This will help with the development of comprehensive, comparative maize baseline information for the Southwestern United States materials, and will be documented in the Genetic Resources Information Network database (GRIN).

Maize morphological diversity is affected by many factors. These factors will be compared to the relationships found in the classification in order to expand the understanding of maize diversity as it is impacted by the geography, climate, language group, cultural relationships and agricultural methods of the ethnic groups in the Southwest.

Previous studies have identified two primary races in the Southwest with many intermediates. The results of this study will be compared to those of previous studies to confirm and/or clarify the differences among the races.

Mexican landraces were included in this study and Midwestern varieties served as controls. Their traits and relationships with the Southwestern landraces will be examined. Understanding the relationships between these maize accessions and Southwestern landraces can provide insight into the migration patterns of maize and peoples, and the relationships of commercial maize to Southwestern landraces.

LITERATURE REVIEW

Maize Diversity

Maize is a very diverse crop species. Kuleshov (1933) remarked on its amazing diversity by noting that maize is grown from 57 degrees north to 35 degrees south latitude, from below sea level to 3000 m, and in areas with annual precipitation ranging from 250 to 5000 mm. These wide geographic and environmental ranges contribute to extensive morphological variation, which Anderson (1943) claims to be the greatest of all cultivated plants. In a study of worldwide maize diversity, average plant height ranged from 60 to 700 cm and leaf number from 8 to 48 (Kuleshov, 1933). Southwestern landraces represent a subset of this diversity, with ranges of plant height from 80 to 295 cm and leaf number from 10 to 21 in this study.

The diversity of maize is a result of many different types of selection pressures. Adaptation is affected by environmental and cultural selection, geographic isolation, genetic drift, and mutation (King, 1994). Environmental selection pressures can be attributed to differences in elevation, precipitation and temperature. Cultural factors are important selection pressures, and maize diversity is a reflection of the histories and attitudes of the cultures where it is grown (Anderson, 1943). The impact of cultures on maize variability and adaptation is complex and artificial selection can lead to rapid phenotypic evolution and change (Wright et al., 2005). Some traits such as ear length and row number are consciously selected for because of the importance of the ear for human consumption (King, 1994). Kernel color is also consciously selected for because of its importance in rituals, and for its capability to encode information about ecological, dietary and medicinal traits (Hernandez Xolocotzi, 1985). Some traits are unconsciously selected for because they are linked to selected traits, while other traits are not influenced at all by cultural selection (King, 1994). The impacts of cultural selection can vary within one landrace or those of an entire region and contribute to wide diversity.

Southwestern Environment

The Southwestern region of the United States has a highly variable climate, with wide variations in temperature, precipitation and elevation. Climatic maps of the Southwest, with collection locations of the maize landraces included in the study, were developed in DIVA-GIS v. 5.0 (www.diva-gis.org), using source data from GRIN (Appendix Figures 13-15). The Southwest's relative isolation, both geographically and climatically, has facilitated maize diversification by isolating individual landraces in specific environments (Carter and Anderson, 1945). Variation in climatic factors is important in understanding the environmental limitations on agricultural systems and maize diversity. Maize diversity can also be influenced by the agricultural and subsistence methods used by different ethnic groups.

Environments in the Southwest range from the Sonoran desert in southern Arizona to the Colorado Plateau in northern New Mexico. Within these broad climatic regions, localized variations in microclimate have also impacted maize diversity (Carter and Anderson, 1945). The Pueblo, Hopi and Navajo ethnic groups live on the Colorado Plateau in northern New Mexico and Arizona and along the Rio Grande Valley in New Mexico. This area is characterized by high elevation, high precipitation, low temperature and a short growing season (Table 1). The Sonoran desert is primarily occupied by the Tohono O'odham (formally the Papago) and Pima-Maricopa. This area is characterized by lower elevation and precipitation, higher temperature and a longer growing season. The Yuman groups live along the Colorado River, with the Upland Yuman in northwestern Arizona and the River Yuman in southwestern Arizona. The Apache live in the mountains of central Arizona. Jorgensen (1983) grouped Southwestern cultures into four major environmental types; the Pima, Tohono O'odham and Yuman on the Gila, Salt and Colorado Rivers in southern Arizona, the Upland Yuman in northern Arizona, the Apache in central New Mexico, and the Pueblo, Hopi and Navajo in northern New Mexico and Arizona. Within the Pueblos of New Mexico, three subgroups were distinguished; the Western Pueblos (Hopi, Zuni and Acoma), the Eastern Keresan (Zia, Santo Domingo and Cochiti), and the Eastern Pueblos (Santa Clara and Taos).

Table 1: Weather data near maize landrace collection sites [a]

Location	Ethnic Group	Environment	Annual precipitation (mm)	Average July high/low (C)	Growing Season (days) [b]	Elevation (m)
Taos, NM	Taos Pueblo	CO Plateau	312	29/11	104	2128
Alcalde, NM	San Juan Pueblo	CO Plateau	251	32/13	125	173
Bernalillo, NM	San Felipe Pueblo	CO Plateau	225	34/15	142	1536
Santa Fe Airport, NM	Santo Domingo Pueblo	CO Plateau	248	30/14	147	1926
Cochiti Dam, NM	Cochiti Pueblo	CO Plateau	309	33/16	162	1695
Jemez Springs, NM	Jemez Pueblo	CO Plateau	436	30/13	141	1905
Los Lunas, NM	Isleta Pueblo	CO Plateau	231	34/16	153	1475
San Fidel, NM	Acoma Pueblo	CO Plateau	243	32/13	122	1865
Laguna, NM	Laguna Pueblo	CO Plateau	250	32/15	134	1768
Zuni, NM	Zuni	CO Plateau	303	32/12	113	1951
Keams Canyon, NM	Hopi	CO Plateau	254	32/13	113	1893
San Carlos, AZ	Apache	Central AZ	291	38/20	184	805
Cibecue, AZ	Apache	Central AZ	471	33/13	126	1524
Kayenta, AZ	Navajo	CO Plateau	195	33/16	146	1728
Supai, AZ	Havasupai	CO River	217	38/19	171	975
Tuweep, AZ	Walapai	CO River	308	34/18	189	1457
Parker, AZ	Mojave	Sonoran desert	122	42/25	235	128
Bullhead City, AZ	Mojave	Sonoran desert	155	44/26	308	177
Maricopa, AZ	Maricopa	Sonoran desert	187	42/24	201	378
Sells, AZ	Tohono O'odham	Sonoran desert	301	38/22	108	722

[a] Information adapted from http://www.wrcc.dri.edu

[b] 90% probability of freeze free days

Elevation and growing season create important limitations in agricultural systems, with water availability being the primary limiting factor in the Southwest. Differences in the quantity and timing of water application contribute to the development of diverse landraces, by creating different environmental selection pressures. Information on agricultural systems was obtained from Robbins et al. (1916), Hill (1938), Castetter and Bell (1942), Castetter and Bell (1951), Ortiz (1979), Ortiz (1983), Kintigh (1984) and Muenchrath (2002).

Ethnic groups near permanent water sources relied primarily on irrigation in their agricultural systems (Table 2). This includes most of the Pueblo tribes on the Rio Grande and its tributaries, the Havasupai on the Colorado River, and the Zuni. Pueblos on more intermittent tributaries or farther from a permanent water source, like the Acoma and Laguna Pueblos, practiced more dryland farming then the other Pueblo cultures. Farming on alluvial fans (akchin farming) was also common throughout the Southwest and was utilized by the Hopi, Zuni, and Tohono O'odham. For the Pima and Mojave on the Gila and Colorado Rivers, respectively, the annual or biannual floods provided moisture for crops and some canals were also used to hold irrigation water. While each culture had a dominant method of providing water, a variety of methods were used within each culture, depending on the field location and its parameters. Santa Clara Pueblo, for example, would often have three field locations with different water sources. Different maize landraces are suited to these different field microclimates.

Growing season limitations and water availability determined suitable maize planting dates (Table 2). For the Pueblo, Hopi, Havasupai, Apache, and Zuni groups with a shorter growing season, planting was done in April through June. The Mojave, Pima, Maricopa, and Tohono O'odham groups have a longer growing season and planted one crop after the danger of frost had past and a second crop in July or August after the flooding of the river or the summer rains.

The importance of agriculture in providing food varies among ethnic groups in the Southwest, and impacts both cultural factors and maize diversity within ethnic groups. In southern Arizona the percentage of the diet derived from agricultural production was 60 to 70% for the Pima, 20% for the Tohono O'odham and 25 to 30% for the Maricopa. The Colorado River Yuman were similar to the Maricopa with 30 to 50 %. The Western Apache obtained about 25 % from agricultural production, which includes food that was stolen. The

Table 2: Traditional agricultural practices in the Southwest [a]

Ethnic group	Water source [b]	Planting date [b]	Harvest date [b]
Santa Clara Pueblo	Irrigation	NA	NA
Isleta Pueblo	Irrigation	NA	NA
Cochiti Pueblo	Irrigation, arroyo mouth	NA	NA
Santo Domingo Pueblo	Irrigation	NA	NA
Zia Pueblo	Irrigation	NA	NA
Laguna Pueblo	Irrigation, dryland	NA	NA
Acoma Pueblo	Irrigation, dryland	NA	NA
Hopi	Floodwater, arroyo mouth	April, May-June	mid July
Havasupai	Irrigation	mid April	June-fall
Mojave	Annual flood	NA	Sep-Oct
Maricopa	Floodwater	NA	May-June, Oct-Nov
Tohono O'odham	NA	July rain	NA
Pima	Floodwater, canal irrigation	Spring, mid summer	July, Oct
Western Apache	NA	April	Oct
Navajo	Traditionally no irrigation	NA	NA
Zuni	Sophisticated irrigation	NA	NA

[a] Information obtained from Robbins et al. (1916), Hill (1938), Castetter and Bell (1942), Castetter and Bell (1951), Ortiz (1979), Ortiz (1983), Kintigh (1984) and Muenchrath (2002)

[b] NA-this information was not found

Pueblos obtained approximately 50% of their diet from agriculture (Jorgensen, 1983). Environment is important in determining the potential of agriculture as a subsistence method, however some ethnic groups with similar environments, such as the Tohono O'odham, Pima and Maricopa, had differing reliance on agriculture for subsistence. Jorgensen (1983) found that dependence on agricultural methods for subsistence varies more because of cultural factors than environmental factors. Cultures with higher reliance on agriculture, in turn, had larger communities, higher population densities and more trade (Jorgensen, 1983).

Southwestern Culture

Understanding the differences between Southwestern cultures and their agricultural practices can provide insights into the relationships between cultures, agricultural systems

and maize landraces. Similar linguistic or cultural histories impact relationships between ethnic groups, which affects how maize landraces developed and were dispersed. Twenty-two ethnic groups are represented in this study (Figure 1). Figure 1 was developed in DIVA-GIS v. 5.0 (www.diva-gis.org), using source information for the maize landraces from GRIN. These ethnic groups are distinguished by history, language, traditions and relationships. Multiple ethnic groups may share a common language and the environments occupied by these ethnic groups can be quite diverse. The interaction between cultural factors and environment is related to maize adaptation and diversity. Cultural and language information was obtained from Ortiz (1979), Ortiz (1983) or Malinowski and Sheets (1998), unless noted otherwise.

Four major prehistorical cultures are recognized in the Southwest, including the Hohokam, Ancestral Puebloans (Anasazi), Mogollon and Patayan. Differences among these ancient cultures have lead to the linguistic and cultural differences seen today. The Mogollon lived in the mountainous areas of eastern Arizona and southern New Mexico. The Anasazi occupied the Colorado Plateau in northern New Mexico and Arizona. They used dry farming and irrigation based agricultural and are the ancestors of modern Pueblo people. The Hohokam lived in the deserts of southern Arizona and were split into Desert and River groups. The River groups are well known for their extensive network of irrigation canals. The Tohono O'odham and Pima are considered by some to be the descendents of the Hohokam culture. The Patayan lived in the area surrounding the lower Colorado River. They relied on the annual floods of the river for their agricultural systems. Little is known about their culture, though there are similarities with modern Yuman cultures.

Five language groups are represented in this study (Table 3). Many of the groups are subdivided and often there are different dialects spoken by ethnic groups in the same language family. The Uto-Aztecan family is divided into two major groups, Sonoran and Shoshonean. The Piman languages belong to the Sonoran group and the Hopi languages to the Shoshonean. The Uto-Aztecan family may be related to the Kiowa-Tanoan family. The Kiowa-Tanoan family consists of three groups, Tewa, Tiwa, and Towa. The Tiwa group is further subdivided into a southern and northern branch. The Apachean languages are part of the Southern Athapaskan subgroup of the Athapaskan family, which also includes a Northern and Pacific Coast subgroup. The Yuman family consists of two major divisions,

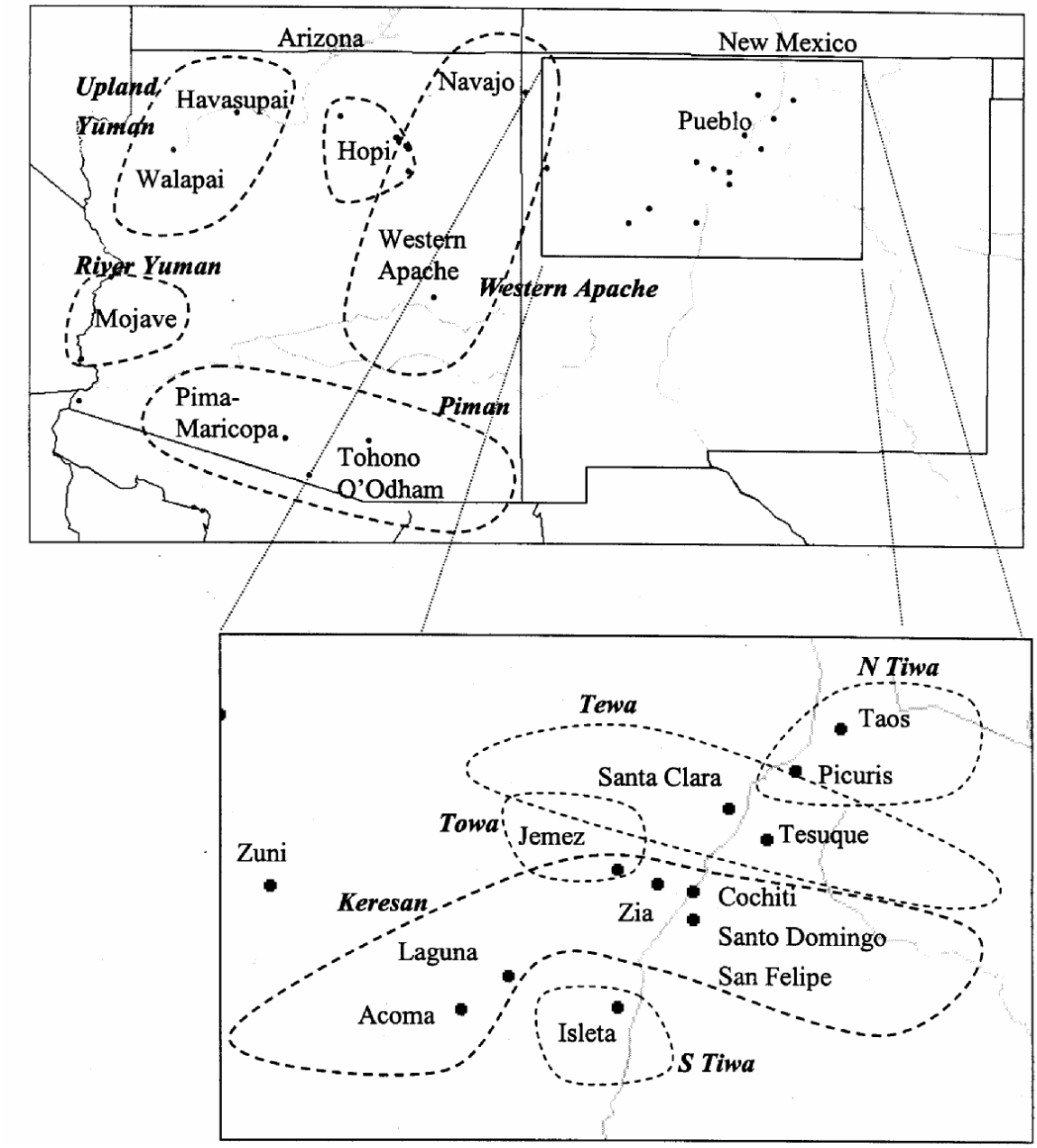

Figure 1: Geographic location of the ethnic groups represented in this study overlaid with language groups (in italics)

Table 3: Language families and groups of Southwestern ethnic groups [a]

Language Family	Language group	Ethnic Group
	Keresan	Acoma Pueblo
		Cochiti Pueblo
		Laguna Pueblo
		Santo Domingo Pueblo
		San Felipe Pueblo
		Zia Pueblo
	Zuni	Zuni
Kiowa-Tanoan	Tewa	Santa Clara Pueblo
		Tesuque Pueblo
	Tiwa	Picuris Pueblo
		Taos Pueblo
		Isleta Pueblo
	Towa	Jemez Pueblo
Uto-Aztecan	Hopi	Hopi
	Piman	Tohono O'odham
		Pima-Maricopa
Apachean	Western Apache	Navajo
		San Carlos Apache
		White Mountain Apache
Yuman	Upland	Havasupai
		Walapai
	River	Mojave

[a] Information derived from Ortiz (1979)

with the Upland and River Yuman both in the same division. The Keresan group consists of a set of very similar languages, with minor differences between the western Keresan (Acoma and Laguna) and the eastern Keresan Pueblos. There are no known languages that are closely related to Keresan. The Zuni group also has no close relatives and consists of only one language.

Jorgensen (1983) examined the relationships between the cultural traditions of ethnic groups in the Southwest. Four different groups were found that have similar cultural traditions: the Piman, Apachean, Yuman and Pueblo. Within the Pueblo group there is a range of similar traditions from Tanoan to Eastern Keresan to Acoma to Zuni to Hopi (Jorgensen, 1983). The cultural distinctions between ethnic groups are similar to those found with language group.

Language and cultural differences can lead to differences in relationships between cultural groups. Hostile or friendly relations can impact trade and exchange of maize and other agricultural practices. Among the Yuman, the Mojave had hostile relationships with the Pima and the Walapai and were a partial reason for the Maricopa leaving the Colorado River. Jorgensen (1983) found that the hostile behavior of the Mojave and Apache had a greater impact on subsistence and economic organization than the influences of environment on these factors. Within the Pueblos, the North Tiwa were somewhat isolated from the other Pueblos geographically and had limited interaction with them and strained relationships with each other. People living in Taos Pueblo had more continuous contact with the Plains tribes than the Pueblo tribes. The Havasupai had good relations with the Hopi.

Some of the interactions between cultures occurred as a consequence of migrations into and within, the Southwest. These migrations assisted in the spread of maize agriculture and provided new opportunities for maize diversification from the diffusion of information and maize between groups. Two cultures in particular, the Navajo and Apache, arrived in the Southwest later than other groups and borrowed agricultural techniques from groups already present. The Navajo arrived in the Southwest around 1000 years ago. They were strongly influenced by the Pueblos, even though they remained culturally distinct. The Navajo displaced the Havasupai in the early 1800's. The Havasupai then migrated to Supai canyon in western Arizona. The Western Apache arrived in the Southwest in the 1500's. They borrowed agricultural traditions from the Western Pueblos or the Navajo.

The arrival of the Spanish into the Southwest directly impacted Native American groups and affected the interactions between them. The extent of the impact of the Spanish was affected by the varying degrees of geographic isolation of the cultures. Many of the Yuman groups had little contact with the Spanish, in particular the Mojave. The nearby Walapai had first contact with Europeans in the 1770's, but were mostly isolated until the mid 1800's. However, the Havasupai are related to the Walapai. These two groups may only be distinct cultures as a result of white contact and influence. Within the Pueblos, geographic isolation was also important. Taos is the most isolated of Eastern Pueblos and is farther removed from the centers of Spanish influence. The isolation of Picuris delayed the impact of the Spanish there by about 50 years.

The presence of, and conflict with, the Spanish in New Mexico led to the Pueblo Revolt in 1680, which changed the relationship of the Pueblo groups to the Spanish and to each other. The Hopi had limited Spanish contact before the Revolt, but this contact was reduced further after the Revolt. The Zuni, despite being the first Pueblo encountered by Europeans and being a major trading hub, had little contact with Europeans after the Pueblo Revolt, until the 1880's. The Pueblo Revolt caused some people to migrate and shift within the Pueblo tribes. Some refugees migrated to the territory where the Navajo lived. Others formed the Laguna Pueblo after the Spanish re-conquest in the late 1600's. This Pueblo is a combination of Keresan, Shoshone, Tanoan, and Zuni people. Other migrations also occurred within the Pueblos. Some Tewa groups settled in villages on the First Mesa, with the Hopi, in 1700. Some members of the Laguna Pueblo migrated to the Isleta Pueblo in the late 1880's.

In more recent times the creation of reservations impacted cultural relations by splitting and combining different ethnic groups. The Mojave were split into two reservations in the mid to late 1800's; Ft. Mojave and the Colorado River Reservation. The Maricopa, who are culturally similar to the Mojave, joined the Pima in the late 1700's, and both occupy the Gila River Indian Community.

Maize racial grouping

One of the goals of classification is to group maize landraces into races. Anderson (1942, p. 71) defined a race as a "group of related individuals with enough characteristics in common to permit their recognition as a group." Harlan (1992) defined a race as a distinct type that originated in a specific geographical region, at a specific time, with distinct morphology, geo-distribution, ecological adaptation, and breeding behavior. Use of these definitions delineates groups of landraces on the basis of certain morphological and ecological features. The choice of these features affects how landraces are grouped into races. Anderson (1942) compared classifying maize into races with trying to distinguish human races, because of the difficulty of defining distinct races in the presence of a continuum of variability. The grouping of landraces into races is therefore necessarily flexible and is focused on understanding general similarities and trends among landraces.

History of maize classification

There has been interest in maize classification for over a century. Understanding previous attempts at classification is important in evaluating the results of this and other studies. Sturtevant (1880) was the first to attempt classification and used kernel color and endosperm type. This approach is useful for indexing, but not for understanding relationships between landraces, since the change from flint to flour endosperm is controlled by one gene (Anderson, 1945). Sturtevant also noticed that some characteristics are influenced by environment and differ when maize is planted in different locations. The influence of the environment on morphology has challenged classification since then. Kuleshov (1933) grouped maize landraces based on endosperm types. Eight groups were defined; with the main groups (flint, flour, dent, and pop) having a specific botanically determined geographic distribution and location of greatest diversity. Floury endosperm is determined to be the most ancient type because it has the most variability. Kuleshov (1933) also grouped maize into six vegetative types; northern, common, central Mexican, Central American, Boyaca and Peru and Persian.

In the 1940's several studies were done on maize from the Southwest, including Longley (1938), Anderson and Cutler (1942), Anderson (1945), and Carter and Anderson (1945). These will be discussed more thoroughly later. In the mid 20th century there was an effort to characterize and classify the maize of Central and South America. The Races of Maize books cover the maize of South America (Cutler, 1946), México (Wellhausen et al., 1952), Central America (Wellhausen et al., 1957), Colombia (Roberts et al., 1957), Cuba (Hatheway, 1957), Brazil (Brieger et al., 1958), Bolivia (Ramirez et al., 1960), the West Indies (Brown, 1960), Chile (Timothy et al., 1961), Perú (Grobman et al., 1961), Ecuador (Timothy et al., 1963), Venezuela (Grant et al., 1963), Portugal (Costa-Rodrigues, 1971), Brazil (Paterniani and Goodman, 1977), India (Singh, 1977), Yugoslavia (Geric et al., 1989), and Paraguay (Salhuana and Machado, 1999). These books provided the basis for many further classification studies and were followed by more extensive research on Central and South American maize. Many of these more recent studies used numerical taxonomic methods, which are better able to clarify the relationships between landraces than previous visual classification methods. Goodman and Bird (1977) and Bird and Goodman (1977)

examined landraces from Latin America. Bird and Goodman (1977) also examined the relationships between landraces and their uses and environment. Sanchez G. and Goodman (1992) studied Mexican and North and South American landraces in an effort to find evidence of the dispersal paths of maize. More recent studies have been done in Spain, Italy, and France (Gallarreta and Alvarez, 2001, Alvarez and Lasa, 1987, Llaurado and Moreno-Gonzalez, 1993, Gouesnard et al., 1997, and Ordas, et al., 1994). Camussi (1979) examined the correlation of maize diversity with geographic origin in Italy. Classification has also been done with sweet corn (Revilla and Tracy, 1995) and groups of inbreds (Mumm and Dudley, 1994).

Southwestern maize classification

Longley (1938) looked at the average number of chromosome knobs of maize from 33 ethnic groups in the United States. Knob number increased from north to south within the United States. The Southwest groups did not show much variation among themselves, but were very distinct from maize in the rest of the United States. Within the Southwest, Navajo, Pueblo, Hopi and Pima maize had the highest number of chromosomes knobs. Mescalero Apache maize had an intermediate knob number and Walapai, Zuni and Tewa Pueblo maize had significantly lower knob numbers. It is theorized that Zuni and Tewa maize are a mixture of maize from the Pueblos and northern tribes.

Anderson and Cutler (1942) and Anderson (1945) found two major groups in the Southwestern United States, the *Pueblo* and the *Pima-Papago*. The *Pima-Papago* (Tohono O'odham, Yuman, and other southern Arizona groups) ears were relatively uniform, had white or yellow kernels, and had small kernels and cobs. *Pueblo* ears were more varied with many kernel colors, big cobs, shanks, and kernels, and twice as many tassel branches as the *Pima-Papago* types.

Carter and Anderson (1945) also found two extremes of Papago and Pueblo maize, in a more extensive study. Measurements were taken on ears of landraces collected from Southwestern ethnic groups. Landraces were classified based on variable groups, into a Mexican and Eastern complex. The Mexican complex was defined by ear taper, high row number and denting. The Eastern complex was defined by enlarged butt, straight rows, wide kernels, and wide shank diameter. The Papago group, which includes Tohono O'odham

(formally Papago), Pima, Yuman, Mojave and Cocopa maize, was found to be uniform and similar. The Pueblo maize was more variable, with the eastern Pueblo maize having more Eastern complex characteristics. Hopi and Zuni maize had the least Eastern type influence. The Tohono O'odham and eastern Pueblo maize were on the two morphological extremes, with the Keresan Pueblo maize having intermediate morphology. The maize from each ethnic group was categorized as *Pueblo*, *Pima-Papago* or intermediate.

Carter (1945) distinguished Pueblo and Papago maize using butt type, ear size, grain size, row number, and grain endosperm characteristics. These traits were highly variable within the Pueblo maize, with Hopi, Zuni, and the Western Keresan Pueblos (Acoma and Laguna) being the most distinct.

Brown and Goodman (1977) described nine racial complexes in the United States, using data from Carter and Anderson (1945). Three of these complexes are from the Southwest, including *Pima-Papago*, *Southwestern 12-row*, and *Southwestern semi-dent*. *Pima-Papago* ears are small. *Southwestern 12-row* is equivalent to the Eastern complex described by Carter and Anderson (1945), with short plants and many tillers. This complex is most common in the eastern Pueblos and is similar to the Northern Flints. *Southwestern semi-dent* is similar to *Southwestern 12-row,* except for the presence of dent endosperm.

Doebley et al. (1983) studied 45 landraces from 21 ethnic groups in the Southwest. Unlike the previous studies that were based on morphology, this classification was based on isozyme data. The results of classification were compared with environmental and social factors. No distinct clusters were found, and the landraces fell along a continuum. The Western Keresan Pueblo and Tohono O'odham maize were on the extremes with the Tewa and Tiwa Pueblo maize more intermediate. Zuni, Walapai, and Mescalero Apache maize classified as distinct groups. Havasupai maize classified near the Western Keresan maize, Mojave near the Tewa and Hopi near the Western Keresan. There was some correlation between the relationships between landraces and Pueblo social organization. The Apache and Navajo groups had the greatest variation between landraces, which could be a factor of their semi-nomadic lifestyle.

Adams et al. (2006) conducted research with 123 landraces, using ears harvested from the New Mexico 2005 field in this study. The landraces were grouped based on a visual assessment of ear characteristics. Several ear traits were measured, including ear length and

weight, shank diameter and row number. These measurements were used in a principal component analysis and a discriminate analysis. There was a strong correlation between visual classification and classification based on the discriminate analysis. Four major groups were delineated, with 27 subgroups. The first three groups all have long ears, with distinctions made between large, medium and small ears. A fourth group contains shorter, wider ears. Subgroups were distinguished by kernel color and endosperm type. The groups were well correlated with ethnic group and geography. Group one contained Rio Grande, Western Pueblo, Havasupai and Navajo landraces with flour endosperm and a range of kernel colors. Group two contained southern Arizona, northern Mexican, lower Colorado River, Navajo and Apache landraces with various endosperm types and white or yellow kernels. Group three contained Rio Grande, Western Pueblo, Navajo and Mexican landraces that were more intermediate in size, with a range of endosperm types and colors. Group four contained landraces with dent endosperm.

All these studies, with the exception of Longley (1938), found a distinction between the Papago and Pueblo maize. However, differences do appear between the classification of Carter and Anderson (1945) and Doebley et al. (1983). In Carter and Anderson (1945) Tohono O'odham maize is closest to Havasupai followed by Hopi, Zuni, Navajo, Keresan, Tiwa and Tewa maize. Doebley et al. (1983) finds the opposite relationship with Tohono O'odham maize closest to Tewa followed by Mojave, Tiwa, Eastern Keresan, Navajo, Western Keresan, Havasupai, and Hopi. Mojave maize is placed in the *Pima-Papago* group in Carter and Anderson (1945) and Doebley et al. (1983) finds that Mojave is closer to the Pueblo maize, even though its morphology is similar to Pima-Papago maize. These differences may be due to the fact that morphology and isozymes represent different measures of maize diversity. While isozymes give an indication of the genetic relationships between maize, they are not well correlated to morphological measures of diversity and may be influenced by different selection pressures. This would impact classification results. The differences between these studies are important in trying to understand specific maize landraces and ethnic groups. However, the similarities between these studies provide ample evidence for a distinction between Pueblo and Papago maize.

Maize racial designation

Racial designation consists of grouping maize landraces into races. Anderson (1943) noted that the extremes of variation in maize tend to be divergent, with many intermediates. The presence of intermediates makes racial designation difficult.

There has been little racial designation done on individual Southwestern maize landraces. The two racial groups of *Pima-Papago* and *Pueblo* have been extensively described and documented (Anderson and Cutler, 1942, Anderson, 1945, Carter and Anderson, 1945, Carter, 1945, Brown and Goodman, 1977). However, information about racial designations of current maize landraces is lacking. Carter and Anderson (1945) and Doebley et al. (1983) both examined landraces within different ethnic groups in the Southwest. However, only Carter and Anderson (1945) categorized maize into racial groups of *Pima-Papago*, *Pueblo* or intermediate (Table 4). Landraces from the southern Arizona ethnic groups were assigned to *Pima-Papago*, some of the Pueblo landraces were assigned to *Pueblo*, and other Pueblo and Yuman landraces were assigned as combinations of *Pima-Papago*, *Pueblo* or intermediate. These designations assume that all the landraces evaluated from an ethnic group are similar and belong to the same race, and does not allow for specific racial designation of individual landraces within an ethnic group.

More recently, some racial designations have been posted in the Germplasm Resources Information Network (GRIN). Some of the landraces used in this study have been assigned a race in GRIN, primarily by the seed donor or by curator review (Appendix Table 21). Five landraces from the Tohono O'odham ethnic group are assigned as *Pima-Papago*. Five Hopi and one Navajo landraces have been assigned as *Pueblo*. Seven Tohono O'odham and two Hopi landraces are assigned as *Southeastern American Southern Dent*. The control and Mexican landraces used in this study have been assigned to races including *Southeastern American 8-row*, *Northeastern North American Flint and Flour*, *Cornbelt dent*, *Dulcillo de Noreste*, *Cristalino de Chihuahua*, *Tuxpeno Norteno*, *Chapalote* and *Reventador*.

Table 4: Racial groups assigned to the maize of Southwestern ethnic groups by Carter and Anderson (1945)

Ethnic group	Race
Tohono O'odham	*Pima-Papago*
Yuman	*Pima-Papago*
Mojave	*Pima-Papago*
Havasupai	*Pima-Papago* and Intermediate
Hopi	Intermediate and *Puebloan*
Zuni	Intermediate and *Puebloan*
San Felipe Pueblo	Intermediate and *Puebloan*
Acoma Pueblo	Intermediate and *Puebloan*
Laguna Pueblo	Intermediate and *Puebloan*
Cochiti Pueblo	Intermediate and *Puebloan*
Taos Pueblo	*Puebloan*
Tesuque Pueblo	*Puebloan*
Isleta Pueblo	*Puebloan*
Jemez Pueblo	*Puebloan*
White River Apache	Intermediate
Navajo	Intermediate and *Puebloan*

Appropriate classification variables

The morphological characteristics used in classification can determine how well the relationships between landraces are ascertained. It is generally agreed that the variables used should reflect a broad genetic base. A variable with multiple genetic factors is likely to have one origin and landraces with a similar value of this variable are therefore likely to be related (Anderson, 1943).

The first major study to address the appropriateness of variables for classification was by Goodman and Paterniani (1969). They acknowledged that racial means are affected by the environment and offered three ways to reduce environmental effects and interactions. Landraces can be grown in several different environments and the mean across environments can be used in classification, the effect of the environment on the landraces can be used for classification, or variables that are not strongly affected by environment can be used. Goodman and Paterniani (1969) calculated a repeatability factor that can be used to determine which variables are most affected by environment. Repeatability is a ratio of the analysis of the main effect of genotype divided by the main effect of environment and the

genotype by environment interaction. A low repeatability value indicates that the difference seen between landraces is due more to environmental effects and interactions than racial differences. In their analysis of 111 variables and 55 landraces of South American maize, they determined that reproductive characters are least affected by the environment and therefore best for use in classification.

The repeatability factor was used by Sanchez G. and Goodman (1992) to classify Mexican landraces. Tassel, kernel and ear characteristics were least affected by environment, agronomic characteristics were moderately affected, and cupule, vegetative and spikelet characteristics were strongly affected. This is contrary to what Goodman and Paterniani (1969) found, where both reproductive and vegetative traits were minimally affected by environment. A minimum list of vegetative and reproductive characteristics to use in classification was given, based on the repeatability measure and the correlations among variables. It included leaf number, branched part of the tassel/total tassel length, spike internode length, male glume length, kernel width, rachis segment length, pith diameter, ear diameter/ear length, and kernel width/kernel length. In addition, the repeatability in this study was compared to that calculated in other studies with similar variables. The correlation between repeatability factors in different studies ranged from 0.25 to 0.88. The differences in repeatability between studies were attributed to different genetic materials, environments and characteristics used in the studies. The choice of variables based on repeatability is therefore somewhat specific to the maize accessions and locations used. Several other studies have also used the repeatability measure to find appropriate characteristics for classification, including Sanchez (1983), Ortiz (1985), Llaurado and Moreno-Gonzalez (1993) and Galarreta and Alvarez (2001).

Another method to evaluate the usefulness of variables for classification is by calculating the coefficient of variation. Variables with a high coefficient of variation are limited for use in classification because the differences between landraces may be obscured by the genetic and environmental variability within landraces (King, 1994). This method provides a useful measure of the environmental effect on different variables.

The use of many variables is useful for understanding the relationships between landraces. Many variables are often needed to resolve the variation among landraces (Bird and Goodman, 1977), and a reduction in variables can considerably change classification,

despite high correlations among variables (Sanchez G., 1989). It is also beneficial to include many variables when working with a large data set (Rincon et al., 1996). With limited resources, a reduced set of variables is important in classification. However, the use of many variables is helpful in explaining the relationship between maize landraces, and should be used when possible.

Numerical taxonomy

Numerical taxonomy has become the accepted method of maize classification. Numerical methods can provide a synthetic description of overall variability in maize accessions that is not possible with visual assessment (Camussi et al., 1983). Two common statistical methods used in maize classification are principal component analysis and cluster analysis.

Principal component analysis is used to create new uncorrelated variables. Often a few principal components describe the majority of the variability in the data. This reduced set of principal components is used as the input in cluster analysis. Most maize classification studies use principal components with an eigenvalue greater than one (Goodman and Bird, 1977, Sanchez G. and Goodman, 1992, Revilla and Tracy, 1995, Llaurado and Moreno-Gonzalez, 1993). These principal components explain much of the variation present in the data and are more useful for classification.

The most common cluster method to use in maize classification is the unweighted pair group method with arithmetic means (UPGMA). It has been used in many classification studies including Goodman and Bird (1977), Sanchez G. and Goodman (1992), Revilla and Tracy (1995) and Galarreta and Alvarez (2001). Several studies have determined that UPGMA is the most appropriate cluster method for maize classification (Rincon et al., 1996, Franco, 1997).

MATERIAL AND METHODS

Genetic resources

This study examined 157 accessions of maize from the United States and Mexico (Table 5). Most of the accessions are from the Southwestern United States, with 40 landraces from New Mexico and 92 landraces from Arizona. Also included are 13 landraces from northern Mexico and 12 controls from the Midwest. The Southwestern landraces used include all the available material in the National Plant Germplasm System from New Mexico and Arizona. Seed for the study was obtained primarily from the North Central Regional Plant Introduction Station (NCRPIS) in Ames, IA, through curator Mark Millard, with the rest coming from seed increases produced by Deb Muenchrath at Iowa State University.

There are 22 Southwestern ethnic groups represented in this study (Table 6). The landraces have been assigned to these groups in GRIN, based on collection information. The design is not balanced with some groups having many more landraces, in particular the Hopi. This unbalance does not indicate that the ethnic groups with more landraces have more variable maize. The number of landraces per ethnic group is more a factor of when and how they were collected, and by whom.

Field study

Two locations were used in this study, New Mexico in 2004 and 2005 and Iowa in 2004. The Iowa site was not used in 2005 due to poor adaptation of the maize to the Midwest environment and disease pressure.

The New Mexico site was located on the New Mexico State Agricultural Research Station near Farmington, NM (36˚ 4’ N, 108˚ W) at an elevation of 1719 m. Soils are primarily Doak loam and Avalon sandy loam. The Iowa site was located at the NCRPIS in Ames, IA (42˚ 03’ N, 93˚ 8’ W) at an elevation of 291 m. Soils are primarily Clarion loam and Nicollet loam.

Field management was done according to the standard weed and pest control practices for maize at the Iowa and New Mexico locations (Table 7). At the Iowa location, nutrients were applied based on the reduced productive capacity of maize landraces, as

Table 5: Accessions included in this study with ethnic group, endosperm type and seed source

Name	Accession Number	Ethnic Group/ Collection Location (GRIN)	Endosperm Type (GRIN)	Seed Source [a]
Hopi White	Ames 22643			NCRPIS
U. S. 13	Ames 26908	Iowa	dent	NCRPIS
Cherokee Flour Corn	Ames 6048	North Carolina	flour	NCRPIS
B73 x Mo17	Ames 19097	Iowa	dent	NCRPIS
Harinoso de Ocho	NSL 2830	Mexico		NCRPIS
Sinaloa 2	NSL 283388	Federal District, Mexico	popcorn	NCRPIS
ARIZONA 046	NSL 67047	Hopi	semident	NCRPIS
ARIZONA 047	NSL 67048	Hopi	semident	NCRPIS
ARIZONA 048	NSL 67049	Hopi		NCRPIS
ARIZONA 050	NSL 67051	Hopi		NCRPIS
ARIZONA 115	NSL 67052	Hopi	semident	NCRPIS
ARIZONA 116	NSL 67053	Hopi	flour	NCRPIS
ARIZONA 117	NSL 67054	Hopi	semiflint/flour	NCRPIS
ARIZONA 118	NSL 67055	Hopi	dent/semident	NCRPIS
ARIZONA 119	NSL 67056	Hopi	flour/flint/dent	NCRPIS
ARIZONA 120	NSL 67057	Hopi	flour/semiflint	NCRPIS
ARIZONA 121	NSL 67058	Hopi	semiflint/semident	NCRPIS
ARIZONA 122	NSL 67059	Hopi	semiflint/semident	NCRPIS
ARIZONA 123	NSL 67060	Hopi	flint/flour	NCRPIS
ARIZONA 124	NSL 67061	Hopi	semiflint/pop	NCRPIS
ARIZONA 125	NSL 67062	Hopi	semiflint/flour/ semident	NCRPIS
ARIZONA 126	NSL 67063	Hopi	semident/dent	NCRPIS
ARIZONA 127	NSL 67064	Hopi	flour/semident	NCRPIS
ARIZONA 128	NSL 67065	Hopi	semiflint/flour	NCRPIS
ARIZONA 129	NSL 67066	Hopi	flour/semident	NCRPIS
ARIZONA 131	NSL 67068	Hopi	semident/flour	NCRPIS
Chuichu White Flour	NSL 68323	Hopi	flour/semiflint	NCRPIS
Chuichu Yellow Flour	NSL 68324	Hopi	flour	NCRPIS
ARIZONA 064	NSL 68325	Hopi	flour/semiflint	NCRPIS
ARIZONA 066	NSL 68326	Hopi	flour/semiflint	NCRPIS
ARIZONA 067	NSL 68327	Hopi	flour/semiflint	NCRPIS
Arizona 075	NSL 68329	Hopi	flour	NCRPIS
ARIZONA 086	NSL 68330	Hopi	flour	NCRPIS
ARIZONA 088	NSL 68331	Hopi	flour	NCRPIS
ARIZONA 093	NSL 68332	Hopi	flour	NCRPIS
ARIZONA 096	NSL 68334	Hopi	flour	NCRPIS
ARIZONA 100	NSL 68335	Hopi	semident	NCRPIS
ARIZONA 135	NSL 68336	Hopi	semident	NCRPIS

[a] NCRPIS-North Central Regional Plant Introduction Center, through curator Mark Millard Muenchrath-Seed increase done by D. Muenchrath in 2002 and 2003

[b] Zuni is not part of the collection at the NCRPIS and does not have a identification number

Table 5: continued

Name	Accession Number	Ethnic Group/ Collection Location (GRIN)	Endosperm Type (GRIN)	Seed Source [a]
Lancaster Sure Crop	PI 213697	Pennsylvania	dent	NCRPIS
Midland Yellow Dent	PI 213712	Kansas	dent	NCRPIS
Papago Flour	PI 213714	Tohono O'odham (AZ)	flour	NCRPIS
Apache White	PI 213728	White Mountain Apache	dent/flint	NCRPIS
Apache Red Cob	PI 213729	White Mountain Apache	flour/flint	NCRPIS
Selection from Apache Red Cob	PI 213730	White Mountain Apache	flour	Muenchrath
Bighead	PI 213732	Oklahoma		NCRPIS
Kokoma	PI 213733	Hopi (Hotevilla)	flour	Muenchrath
NRC 5180	PI 213734	Hopi (Hotevilla)	flour	Muenchrath
NRC 5181	PI 213735	Hopi (Hotevilla)	flour	Muenchrath
Globe Variegated	PI 213736	San Carlos Apache	flour	NCRPIS
Red Navajo	PI 213737	Navajo	flour/flint	NCRPIS
Blue Navajo	PI 213738	Navajo	flour	NCRPIS
Yellow Navajo	PI 213739	Navajo	flint/dent/flour	NCRPIS
Defiance White 1	PI 213740	Navajo	flour	NCRPIS
Wallapai White	PI 213741	Hualapai	flour	Muenchrath
Quapaw Red	PI 213757	Oklahoma	flint	NCRPIS
Albuquerque Pink	PI 213767	Uncertain southwest	flint	NCRPIS
Gourdseed	PI 217405	Iowa	dent	NCRPIS
Longfellow Flint	PI 217408	Iowa	flint	NCRPIS
Tama Flint	PI 217411	Iowa	flint/flour	NCRPIS
Santo Domingo Pueblo	PI 218130	Santo Domingo Pueblo	flour	NCRPIS
Cochiti Pueblo	PI 218131	Cochiti Pueblo	flint/flour	Muenchrath
Mesita Pueblo	PI 218133	Laguna Pueblo	flour	NCRPIS
Tesuque Pueblo	PI 218134	Tesuque Pueblo	sweet	NCRPIS
San Lorenzo Pueblo	PI 218135	Picuris Pueblo	flint/flour	NCRPIS
Tesuque Pueblo	PI 218136	Tesuque Pueblo	flour/flint	Muenchrath
Tesuque Pueblo	PI 218137	Tesuque Pueblo	flour/flint	Muenchrath
Isleta Pueblo	PI 218138	Isleta Pueblo	flour/dent	NCRPIS
Zia Pueblo	PI 218139	Zia Pueblo	flour	NCRPIS
Acoma Pueblo	PI 218140	Acoma Pueblo	popcorn	NCRPIS
Acoma Pueblo	PI 218141	Acoma Pueblo	flint/dent/flour	NCRPIS
San Lorenzo Pueblo	PI 218142	Picuris Pueblo	flint/dent	Muenchrath
Santo Domingo Pueblo	PI 218143	Santo Domingo Pueblo	flour/flint	NCRPIS
Isleta Pueblo	PI 218144	Isleta Pueblo	dent/flour	NCRPIS
Siles Pueblo	PI 218145	Near Cochiti Pueblo	flour	NCRPIS
Mesita Pueblo	PI 218146	Laguna Pueblo	flour	NCRPIS
Mesita Pueblo	PI 218147	Laguna Pueblo	flour/dent	NCRPIS
Isleta Pueblo	PI 218148	Isleta Pueblo	flour	NCRPIS
Taos Pueblo	PI 218149	Taos Pueblo	flint/dent	Muenchrath
Cochiti Pueblo	PI 218150	Cochiti Pueblo	flour	NCRPIS
Cochiti Pueblo	PI 218151	Cochiti Pueblo	flour	NCRPIS

Table 5: continued

Name	Accession Number	Ethnic Group/ Collection Location (GRIN)	Endosperm Type (GRIN)	Seed Source [a]
Taos Pueblo	PI 218152	Taos Pueblo	flint/dent	Muenchrath
San Felipe Pueblo	PI 218153	San Felipe Pueblo	flour	NCRPIS
San Felipe Pueblo	PI 218154	San Felipe Pueblo	dent	NCRPIS
Santo Domingo Pueblo	PI 218155	Santo Domingo Pueblo	dent/flint	NCRPIS
Santo Domingo Pueblo	PI 218156	Santo Domingo Pueblo	flour	NCRPIS
Santa Clara Pueblo	PI 218157	Santa Clara Pueblo	flour/flint	Muenchrath
Zia Pueblo	PI 218158	Zia Pueblo	flour	NCRPIS
Zia Pueblo	PI 218159	Zia Pueblo	flour	NCRPIS
Navajo Tribe	PI 218160	Navajo	flour/flint	NCRPIS
Navajo Tribe	PI 218161	Navajo	flour	NCRPIS
Navajo Tribe	PI 218162	Navajo	flour/dent	NCRPIS
Navajo Tribe	PI 218163	Navajo	flour	NCRPIS
Navajo Tribe	PI 218164	Navajo	flour	NCRPIS
Navajo Tribe	PI 218165	Navajo	flour	NCRPIS
Navajo Tribe	PI 218166	Navajo	flour/dent	NCRPIS
Acoma Pueblo	PI 218167	Acoma Pueblo	flour/flint	NCRPIS
Acoma Pueblo	PI 218168	Acoma Pueblo	flour/flint	NCRPIS
Laguna Pueblo	PI 218169	Laguna Pueblo	flour	Muenchrath
Laguna Pueblo	PI 218170	Laguna Pueblo	flour	NCRPIS
Jemez Pueblo	PI 218171	Jemez Pueblo	flour/dent	NCRPIS
Jemez Pueblo	PI 218172	Jemez Pueblo	dent/flour/flint	NCRPIS
Jemez Pueblo	PI 218173	Jemez Pueblo	flour	NCRPIS
Moencopi Pueblo	PI 218174	Hopi (Moencopi)	sweet/flour	NCRPIS
Moencopi Pueblo	PI 218175	Hopi (Moencopi)	flour	NCRPIS
Moencopi Pueblo	PI 218176	Hopi (Moencopi)	flour	NCRPIS
Moencopi Pueblo	PI 218178	Hopi (Moencopi)	flour	NCRPIS
Papago	PI 218179	Tohono O'odham (AZ)	flour/dent	NCRPIS
Papago	PI 218180	Tohono O'odham (AZ)	dent	NCRPIS
Papago	PI 218181	Tohono O'odham (AZ)	dent/flint	NCRPIS
Papago	PI 218182	Tohono O'odham (AZ)	dent	NCRPIS
Papago	PI 218183	Tohono O'odham (AZ)	dent	NCRPIS
Papago	PI 218184	Tohono O'odham (AZ)	dent	NCRPIS
Papago	PI 218185	Tohono O'odham (AZ)	flour	NCRPIS
Mojave Tribe	PI 218186	Mojave	flour	Muenchrath
Mojave Tribe	PI 218187	Mojave	flour	NCRPIS
Zia Pueblo	PI 218188	Zia Pueblo	flint	NCRPIS
P 69	PI 218189		dent/flint	NCRPIS
Papago	PI 218190	Tohono O'odham	dent	NCRPIS
PAPAGO TRIBE	PI 218191	Tohono O'odham	dent	NCRPIS
Cudu	PI 222285	Navajo	flour	NCRPIS
Navajo Tribe	PI 311229	Navajo	flour	Muenchrath
Mexican June	PI 311243	Virginia	dent	NCRPIS
Ames 728	PI 317674	Havasupai	flour	NCRPIS

Table 5: continued

Name	Accession Number	Ethnic Group/ Collection Location (GRIN)	Endosperm Type (GRIN)	Seed Source [a]
Ames 729	PI 317675	Havasupai	flour	Muenchrath
Ames 732	PI 317678	Havasupai	flour	NCRPIS
Ames 733	PI 317679	Havasupai	flour	NCRPIS
Reids Yellow Dent	PI 408705	Iowa	dent	NCRPIS
Chapalote	PI 420245	Sinaloa, Mexico	flint	NCRPIS
Tawa'ktci	PI 420247	Hopi (Shungopovi)	sweet/flint	NCRPIS
Pala'qua'3	PI 420248	Hopi (Shungopovi)	flour	NCRPIS
sakwa'fqa'3	PI 420250	Hopi (Shungopovi)	flour	Muenchrath
huhni (60 day corn)	PI 420251	Pima-Maricopa	flint/flour/dent	Muenchrath
Onaveno	PI 420252	Sonora, Mexico	flint/dent	NCRPIS
O'odham huuni	PI 451716	Tohono O'odham (AZ)		NCRPIS
Z01-005	PI 474206	Sonora, Mexico	flour	NCRPIS
Z08-003	PI 474209	Sonora, Mexico	flint	NCRPIS
Z03-003	PI 476868	Taos Pueblo	flour/flint	NCRPIS
Z03-004	PI 476869	Hopi (New Oraibi)	flour/semident	Muenchrath
Z06-001	PI 476870	Havasupai (Hopi)	flour	Muenchrath
Chihuahua 138	PI 484413	Chihuahua, Mexico		NCRPIS
Chihuahua 160	PI 484433	Chihuahua, Mexico		NCRPIS
Chihuahua 220	PI 484482	Chihuahua, Mexico		NCRPIS
Chihuahua 128	PI 485116	Chihuahua, Mexico		NCRPIS
Nayarit 15	PI 490921	Jalisco, Mexico		NCRPIS
Dulcillo del Noroeste	PI 490973	Sonora, Mexico	sweet/flint/dent	NCRPIS
Z03-017	PI 503562	Hopi (Kiakochomovi)		NCRPIS
Z01-012	PI 503563	Pima-Maricopa		Muenchrath
Z03-020	PI 503564	Hopi (Bakabi)		NCRPIS
Z04-017	PI 503565	Hopi (Hotevilla)		NCRPIS
Z03-018	PI 503566	Hopi (Hotevilla)		NCRPIS
Z04-015	PI 503567	Hopi (Hotevilla)		NCRPIS
Z10-010	PI 503568	Navajo		NCRPIS
Z01-010	PI 503573	Tohono O'odham (AZ)	flour	NCRPIS
Arizona Maize Germplasm for Saline Environs	PI 508270	Arizona	semident	NCRPIS
Arizona Maize Germplasm for Arid Environs	PI 550563	Arizona		NCRPIS
Coahuila 21	PI 629147	Coahuila, Mexico		NCRPIS
Deb's S. Ghate, Zuni	Zuni [b]	Zuni		Muenchrath

Table 6: Number of landraces in this study assigned to each Southwestern ethnic group [a]

Ethnic group	Number of landraces
Acoma Pueblo	4
Cochiti Pueblo	4
Laguna Pueblo	4
Santo Domingo Pueblo	4
San Felipe Pueblo	2
Zia Pueblo	4
Santa Clara Pueblo	1
Tesuque Pueblo	3
Picuris Pueblo	2
Taos Pueblo	3
Isleta Pueblo	3
Jemez Pueblo	3
Hopi	49
Tohono O'odham	13
Pima-Maricopa	2
Navajo	14
San Carlos Apache	1
White Mountain Apache	3
Havasupai	5
Walapai	1
Mojave	2
Zuni	1

[a] Most ethnic group assignments are from GRIN

compared to commercial maize. Fields were planted in May and harvested in October (Table 8). The New Mexico fields were provided with irrigation through a center pivot system to supplement precipitation.

A randomized complete block design was used with three replications per field. Single row plots were used with a total of 471 plots in 2004 and 465 plots in 2005. Two accessions were excluded in 2005 (PI 508270 and PI 550563). They are mixes of Arizona landraces with Mexican June and do not represent indigenous landraces (GRIN). At the New Mexico site plots were 6.1 m long, with 1.5 m between plots and row spacing of 1.7 m. In Iowa the plots were 7.6 long, with 3 m between plots and row spacing of 1.8 m. After plants were established, plots were thinned to a final population of 19 plants (29,012 plants/ha) in New Mexico and 25 plants (26,375 plant/ha) in Iowa. The different plot sizes and final populations were altered in the two locations to maintain three effective square feet per plant,

Table 7: Herbicide, fertilizer and fungicide applications in the three fields

	Pre-plant herbicide	Pre-plant fertilizer	Additional fertilizer [a]	Fungicide
NM 2004	2.92 L/ha Bicep Lite II Mag 1/8 0.15 L/ha Clarity	224 kg/ha 8-39-15	91 kg N	
IA 2004	2.34 L/ha Harness PPI	336 kg/ha 32-10-10		1.95 ml/L Quadris on 7/12, 7/26, 8/10
NM 2005	2.92 L/ha Bicep Lite II Mag 0.14 L/ha Clarity 0.14 L/ha Lo Vol 6 (2-4, D)	224 kg/ha 5-26-30	105 kg N	

[a] Addition nitrogen fertilizer was applied to the New Mexico fields throughout the growing season using fertigation.

Table 8: Planting date, harvest date and water available for the three fields

	Effective planting date [a]	Harvest date	Precipitation (mm) [b]	Irrigation (mm)
NM 2004	5/21	10/18-10/20	88	596
IA 2004	5/11	10/5-10/13	517	
NM 2005	5/19	10/18-10/20	45	587

[a] In New Mexico the effective planting date was the date of the first irrigation because of low soil moisture at planting. Actual planting dates were 5/12-5/13 in 2004 and 5/10-5/12 in 2005. Some plots were replanted due to predation in the New Mexico field with replants done on 6/2 in 2004 and 5/25, 5/31, and 6/2 in 2005.

[b] Precipitation was calculated from the actual planting date to the harvest date.

given different row spacing. In 2004, *Coix lacryma-jobi* (Job's tears) was planted in between rows of maize in both fields to provide a buffer between plots. This was not repeated in 2005 due to poor germination and growth of the *Coix lacryma-jobi* in New Mexico. In each plot 35 seeds were planted (45 seeds for landraces with low germination, as determined by the NCRPIS).

Variables

In each plot 10 plants were labeled. Measurements were taken on 6 to 8 of these labeled plants (Table 9). During the field season, data was taken on phenological, vegetative and tassel characteristics. Vegetative characteristics were measured after the plot reached 50% anthesis and tassel characteristics were taken after the plot reached 90% anthesis. The primary ear on five plants was harvested, with some additional plant measurements taken at

harvest. Ears were transported to the lab in Ames, Iowa, dried, and data were recorded on ears, kernels and cobs. The variables used are commonly used in classification and characterization studies, with most of the variables taken from a study by Sanchez G. (1989). Several additional variables, including number of nodes to the primary ear, stalk circumference, kernels per row, and cob color, were included and were used for characterization in the Races of Maize books. Ear shape was described by a measure of conicalness, which was determined to be a good variable for classification for Spanish maize (Galarreta and Alvarez, 2001).

Imaging

Images were taken of the plants and tassels in the New Mexico field using a digital camera (Figure 2 and 3). At least one picture was taken for each accession. In the lab, pictures were taken of the ears and ear cross sections for one replication in each field using a Microtek 9800XL scanner (Figure 4 and 5). These images will be provided to the maize curator at the NCRPIS for public use, and also provided to project cooperators.

Grain composition

Grain composition was analyzed on the 2005 New Mexico grain samples. Oil, protein, starch, moisture, and density were measured in April of 2006 using a Foss Infratec 1241 Grain Analyzer. Destructive analysis was also done in order to calibrate the results obtained from the Infratec 1241. This information will be evaluated in another study.

DNA

Tissue samples were collected in Iowa in 2004 and in New Mexico in 2005. Eight samples were collected per accession in New Mexico and 12 per accession in Iowa. Samples were collected early in the season on tissue from a young leaf using Whatman^{TM} cards. The cards were then stored at the NCRPIS for use in DNA extraction in the future.

Table 9: Description of variables measured

Variable	Variable code	Variable description
Phenology		
Emergence (VE)		The date when 50% of the seeds in each plot emerged
Anthesis	days5a, days9a	The date when 50% and 90% of the labeled plants in a plot started shedding pollen
Silking (R1)	days5s, days9s	The date when silk appeared on 50% and 90% of the labeled plants
Maturity (R6)	daysbl	Date that the kernels reached black layer. For each accession only one plot was measured.
Vegetative		
Leaf width (mm)	lwidth	Width at the mid-point of the primary ear leaf
Leaf length (cm)	llength	Length measured on the primary ear leaf from collar to tip along the midrib
Leaf number	leaves	Total number of leaves. Early in the season the fifth leaf of each plant was marked with spray paint in New Mexico. This insured an accurate count of the early leaves that had died.
Primary ear node number	nodes	Number of nodes from the base of the plant to the primary ear node. This measurement was also done using the marked fifth leaf.
Stalk circumference (mm)	circ	The circumference of the main stalk immediately above the insertion point of the primary ear
Plant height (cm)	height	Height from ground level to the top of tassel
Ear height (cm)	earheight	Height from ground level to the insertion point of the primary ear
Tiller number	tiller	Number of tillers
Tassel		
Peduncle length (cm)	peduncle	Length from the collar of the top leaf to the lowermost branch on the tassel
Branching space length (cm)	branching	Length from the lowermost branch to the uppermost branch
Spike length (cm)	spike	Length from the top branch to the tip
Branch number	branch	Number of main branches
Harvest		
Shank (cm)	shank	Length of the shank of the primary ear
Husk number	husk	Number of husks on the primary ear
Blades	blades	Absence or presence of husk blades. This was not measured at the Iowa site.
Extension (cm)	exten	The length of the husk extension beyond the ear. Negative values were not recorded. This was not measured at the Iowa site.

Table 9: continued

Variable	Variable code	Variable description
Ear		
Row number	row	Rows of kernels in the middle of the ear
Kernels per row	kernels	Number of kernels in one row of the ear
Ear length (cm)	elength	Length of the ear
Ear diameter (mm)	diabutt dia14 dia12 dia34	Diameter of the ear was measured at the butt, one quarter, one half and three quarters along the ear length. This measurement included kernels.
Ear weight (g)	tweight	Total weight of the ears from each plot
Ear shape	shape	Described as cylindrical, conical, cylindrical-conical, round, or fascinated (based on GRIN descriptors)
Kernels		
Kernel thickness (mm)	kthick	Thickness of 10 consecutive kernels on the ear
Kernel width (mm)	kwidth	Width of the same 10 kernels measured for thickness
Kernel length (mm)	klength	Length (depth) of the same 10 kernels measured for thickness
Grain weight (g)	tgweight	Total grain weight from each plot
Moisture	moist	Measured on a grain sample from each plot using a GAC 2000 Grain Analysis Computer (Dickey-john Corporation)
100-kernel weight (g)	kw	Weight of 100 kernels
100-kernel volume (ml)	kv	Volume of 100 kernels measured by displacement of water
Cob		
Cob diameter (mm)	cobdia	Diameter measured at mid-point from the apex of the lower glume to the apex of the alicole directly opposite
Cob color	cobc	Classified as white or non white
Rachis diameter (mm)	rachis	Diameter of the rachis
Pith diameter (mm)	pith	Diameter of the pith
Rachis segment length (mm)	rachisseg	Distance between the center of two consecutive cupules

Table 9: continued

Variable	Variable code	Variable description
Growing degree days to emergence, 50% and 90 % anthesis and silk, and black layer (using degrees Fahrenheit)	gdd5a, gdd9a, gdd5s, gdd9s, gddbl	
Leaf area (cm^2)	larea	Leaf width*leaf length*0.75
Plant height/ear number	plantearnum	
Plant height/ear height	plantear	
GDD to 50 % silk/leaf number	gddleafnum5	
Tassel length (cm)	tassel	Total length of the peduncle, branched part, and the central spike
Peduncle/tassel length	pedtass	
Branched part/tassel length	branchtass	
Central spike/tassel length	spiketass	
Individual ear weight (g)	eweight	Total ear weight divided by number of ears
Ear surface area (cm^2)	esurarea	Ear length*ear mid-diameter*3.1416
Ear diameter/ear length	dialength	
Cob diameter/ear diameter	cobeardia	
Conicalness	conical	(((Di-Ds)/2)/(ear length/3))*100 Di-ear diameter one quarter from base Ds-ear diameter three quarters from base (Based on Ordas and de Ron, 1988)
Grain dry weight (g)	dryweight	
Grain weight (10% moisture, g)	weight10	
Grain weight per ear (g)	weightear	Total grain weight divided by number of ears harvested per plot
100 kernel dry weight (g)	kdry	
100 kernel weight (10% moisture, g)	k10	
Kernel width/length	kwidthlength	
Kernel thickness/length	kthicklength	
Kernel thickness/width	kthickwidth	

Figure 2: Plant image of NSL 67066 taken in New Mexico 2005

Figure 3: Tassel image of PI 218142 taken in New Mexico 2005

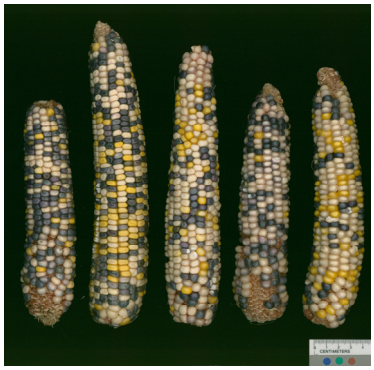

Figure 4: Ear image of PI 213729 from the New Mexico 2005 field

Figure 5: Ear cross section of NSL 67060 from the New Mexico 2005 field

Statistical analysis

Reduction of variables for classification

Some of the variables used in this study were primarily for characterization and may not be useful for classification because of large environmental effects and interactions. It is therefore important to determine which variables are appropriate for classification. A repeatability factor, as described by Goodman and Paterniani (1969), is often used to reduce the variables used in maize classification. Repeatability is not appropriate for use in this

study however, since only two locations were used and many of the accessions were not adapted to the Iowa location. Variables with high repeatability in other studies may not be useful in this study since repeatability factors vary with different genetic materials, environments and variables (Sanchez G. and Goodman, 1992). Instead, variables with a high coefficient of variation (CV) were excluded from further analysis, since the CV statistic provides information about the environmental influence on variables (King, 1994). Other variables were excluded if they did not provide unique information or did not measure a meaningful characteristic.

Analysis of variance

Analysis of variance was based on plot means and calculated for the main effects of accession, replication, environment and ethnic group. In addition, the interaction of accession by environment and ethnic group by environment was calculated.

Interaction analysis

The interaction effects were evaluated further to examine the effect of environment on different accessions and ethnic groups and to expand the interpretation of the cluster results. Analysis of variance was done for individual ethnic groups to calculate the accession by environment interaction within each ethnic group, for the variables that had a significant ethnic group by environment interaction. For variables with a significant ethnic group by environment interaction, landrace means by ethnic group were calculated for each environment (Appendix Table 22).

In addition, a GGE biplot analysis was done. The interaction effect was first calculated in Excel (Microsoft Corporation, 2001) using the following equation: accession by environment mean – accession mean – environment mean + total mean. Interaction effects were used in a GGE biplot analysis. GGE biplots are often used to examine genotype by environment interaction and to evaluate cultivars for breeding programs.

Principal component analysis

Principal component analysis was done using the least square means for each accession. The data from all three environments were combined and accession means were used in the analysis. Goodman and Paterniani (1969) stated that using overall means reduces

the environmental effects and interactions. Analysis was also done using accession means from the two New Mexico environments, because of the environmental interactions found in the analysis of accession by environment and ethnic group by environment interactions. The first two principal components were plotted to visualize clusters. The principal components with eigenvalues greater than one were used for the cluster analysis. Many other studies have used this method to determine how many principal components to use in maize classification and clustering (Goodman and Bird, 1977, Sanchez G., 1989, Revilla and Tracy, 1995, Llaurado and Moreno-Gonzalez, 1993).

Cluster analysis

Clustering was done using the average method. Average clustering, or unweighted pair group with arithmetic means, has been found to be the most appropriate method for maize classification (Rincon et al., 1996, Franco, 1997). The clustering were done using the combined data from all three environments and the data from the two New Mexico environments.

Statistical computing

The analysis of variance, principal component and clustering analyses were done using SAS, v. 9.1 (SAS Institute Inc., 2002-2003). The statistical program, R (The R Foundation for Statistical Computing, 2004), was used for the biplot analysis and for creating the graphics based on the principal components.

RESULTS AND DISCUSSION

Reduction of variables for classification

There were 42 variables included in the principal component and cluster analysis. Variables were excluded from use in classification if they had a high coefficient of variation. These variables include ear shoots on the tillers, tassel peduncle length, peduncle length/tassel length, husk extension and conicalness (Table 10). Several variables were not meaningful and were excluded. Ear shoots on the main stalk were counted at flowering time, and represent the potential prolificacy but not the actual yield. There was a low correlation (0.25) between shoots on the main stalk and number of ears harvested by Adams et al. (2006). The presence or absence of husk blades was not included in the combined analysis since it was not measured in Iowa. Other variables including days to flowering, ear diameters at one quarter and three quarter from the base, and 100-kernel weight were not included since these characteristics were explained well by other variables.

Analysis of variance

Analysis of variance was done for the main effects of accession, replications within the field, environment, ethnic group, and for the interaction of environment by accession and environment by ethnic group. Significant differences between accessions and ethnic groups were found for all variables (Table 11). For most variables there was a significant difference between replications, between environments, and a significant accession by environment interaction. Almost half of the variables examined had a significant ethnic group by environment interaction, including both vegetative and reproductive variables. This differs with the conclusions of Goodman and Paterniani (1969) who determined vegetative characteristics are more affected by the environment than reproductive characteristics. However, it does agree with the conclusion of Sanchez G. (1989), who determined that both vegetative and reproductive characteristics have low environmental effects. Environmental effects impact genotypic expression, as evidenced by the phenotype, and are not confined to vegetative characteristics in this study.

Table 10: Coefficient of variation for all variables, based on combined data from all environments

Variable	Coefficient of variation	Variable	Coefficient of variation
dayse		spiketass	9.37
days5a	4.45	blades	16.72
days9a	4.68	exten	33.20
days5s	5.11	husk	12.54
days9s	5.43	shank	23.89
gdde		row	6.89
gdd5a	9.73	kernels	13.16
gdd9a	10.64	elength	11.01
gdd5s	9.08	diabutt	8.97
gdd9s	10.29	dia14	5.84
tiller	27.32	dia12	5.36
shootmain	23.90	dia34	5.48
shoottiller	56.33	dialength	12.68
height	18.91	conical	34.65
tasselflag	9.71	kthick	7.03
earheight	19.25	kwidth	4.78
leaves	15.76	klength	5.90
nodes	24.56	kwidthlength	6.03
llength	9.39	kthicklength	10.73
circ	9.91	kthickwidth	7.84
lwidthcm	9.70	eweight	23.10
larea	13.95	kw	12.73
plantear	18.42	kv	11.94
GDDleafnum5	14.02	weightear	22.76
branch	18.59	k10	12.12
spike	12.05	cobdia	7.67
branching	16.41	cobc	13.83
peduncle	48.97	rachis	9.40
tassel	10.64	pith	12.42
pedtass	50.77	rachisseg	12.93
branchtass	13.24		

Table 11: Analysis of variance p-values for the main effects of environment and ethnic group and the accession by environment and ethnic group by environment interaction

Variable	Environment	Accession by environment	Ethnic group	Ethnic group by environment
gdd5a	0.0001*	0.0001*	0.0001*	0.6723
gdd5s	0.0001*	0.0001*	0.0001*	0.0001*
tiller	0.1594	0.0002*	0.0001*	0.7670
height	0.0244*	0.0001*	0.0001*	0.2126
earheight	0.0031*	0.0001*	0.0001*	0.0001*
leaves	0.0001*	0.0001*	0.0001*	0.0172*
nodes	0.0001*	0.0001*	0.0001*	0.0002*
lwidth	0.3166	0.0001*	0.0001*	0.6515
llength	0.0385*	0.0001*	0.0001*	0.1401
circ	0.0021*	0.0001*	0.0001*	0.0001*
larea	0.3659	0.0001*	0.0001*	0.2774
plantear	0.2118	0.0001*	0.0001*	0.0012*
gddleafnum5	0.0002*	0.0001*	0.0001*	0.0001*
branch	0.0026*	0.0001*	0.0001*	0.0004*
branching	0.0012*	0.0001*	0.0001*	0.0102*
spike	0.0001*	0.0001*	0.0001*	0.0001*
tassel	0.0113*	0.0001*	0.0001*	0.0001*
branchtass	0.0533*	0.0001*	0.0001*	0.9878
spiketass	0.0063*	0.0001*	0.0001*	0.2380
blades	0.0001*	0.0181*	0.0001*	0.5469
husk	0.0248*	0.2630	0.0001*	0.8053
shank	0.0001*	0.0001*	0.0001*	0.0001*
row	0.0331*	0.2158	0.0001*	1.0000
kernels	0.0001*	0.0025*	0.0001*	0.3105
dia12	0.0004*	0.0001*	0.0001*	0.9159
elength	0.0025*	0.0003*	0.0001*	0.0036*
eweight	0.0088*	0.0001*	0.0001*	0.0001*
weightear	0.0010*	0.0001*	0.0001*	0.0001*
dialength	0.0217*	0.0101*	0.0001*	0.8159
cobeardia	0.0001*	0.0049*	0.0001*	0.0001*
kv	0.2833	0.0001*	0.0001*	0.0055*
k10	0.0240*	0.0001*	0.0001*	0.0001*
kwidth	0.0513*	0.0160*	0.0001*	0.9999
kthick	0.1068	0.0018*	0.0001*	0.5704
klength	0.0057*	0.0001*	0.0001*	0.7855
kwidthlength	0.2323	0.0001*	0.0001*	0.9995
kthicklength	0.0481*	0.0061*	0.0001*	0.8884
kthickwidth	0.0076*	0.0261*	0.0001*	0.9031
cobdia	0.0015*	0.0052*	0.0001*	0.2149
cobc	0.0001*	0.2076	0.0001*	0.9998
rachis	0.0049*	0.0407*	0.0001*	0.7282
pith	0.0173*	0.3560	0.0001*	0.6073
rachisseg	0.0003*	0.0004*	0.0001*	0.0016*

*Significant at the 0.05 level

For variables with a significant ethnic group by environment interaction, a separate analysis of variance was done on the accession by environment interaction by ethnic group. The large-eared Hopi and Tohono O'odham landraces were separated from their respective ethnic groups and grouped together. The landraces with pop and sweet endosperm were also grouped together. The ethnic groups Santa Clara, Walapai, San Carlos Apache and Zuni were not included in this analysis since they are only represented by one landrace.

Landraces of the Hopi and Mexico ethnic groups and the control group had the largest numbers of variables exhibiting a significant accession by environment interaction (Table 12). The landraces in ethnic groups with significant interactions were affected by environment in different ways than landraces in other ethnic groups. One of the causes of this interaction could be a lack of adaptation to the environments used. The control accessions are not adapted to the Southwestern environment, and the Hopi landraces are not adapted to the Midwest environment. The Mexican landraces are not adapted in either environment, though the New Mexico environment is geographically closer to their area of adaptation than Iowa. Environmental effects and interactions are important because they can change the accession means that are used in classification (Goodman and Paterniani, 1969), which can change the results of classification.

The environmental effect on the landraces of individual ethnic groups can be examined further by looking at the landrace means for each ethnic group for variables with a significant ethnic group by environment interaction (Appendix Table 22). Some ethnic groups had landraces that reacted differently to certain environments as compared to the majority of landraces from other ethnic groups. Individual accessions also reacted differently in the three environments (Appendix Table 26-29).

GGE biplot analysis

Significant ethnic group by environment interactions were examined using a GGE biplot constructed from the interaction effects calculated from the accession by environment interaction. The biplots were examined visually, and while individual accessions are affected by environment differently, this technique was not useful for identifying trends or offering clear interpretation of the effects of environment on landraces from different ethnic groups.

Table 12: Analysis of variance degrees of freedom and p-values for the accession by environment interaction of individual ethnic groups

Ethnic group	Degrees of freedom	gdd5s	earheight	leaves	nodes	circ	plantear	gddleaf num5
Cochiti Pueblo	6	0.4090	0.5571	0.6744	0.5432	0.9422	0.2557	0.0807
Santo Domingo Pueblo	6	0.9263	0.1116	0.9063	0.3614	0.1889	0.3499	0.8663
San Felipe Pueblo	2	0.4936	0.4551	0.7408	0.6025	0.1747	0.8343	0.0156*
Zia Pueblo	6	0.4860	0.1431	0.0342*	0.2259	0.4382	0.2061	0.0139*
Acoma Pueblo	4	0.8497	0.7780	0.3030	0.0071*	0.7009	0.8648	0.2046
Laguna Pueblo	8	0.9224	0.9678	0.3868	0.2753	0.5619	0.8244	0.2938
Isleta Pueblo	4	0.1954	0.7437	0.9164	0.5515	0.4344	0.4691	0.6965
Taos Pueblo	4	0.1307	0.2112	0.9386	0.2337	0.5378	0.7932	0.8411
Picuris Pueblo	2	0.7140	0.0174*	0.7429	0.8937	0.1576	0.0289*	0.2824
Tesuque Pueblo	4	0.1614	0.0519*	0.4614	0.1112	0.7050	0.6317	0.0050*
Jemez Pueblo	4	0.2958	0.7147	0.7314	0.8809	0.1169	0.7662	0.5391
Hopi	76	0.0001*	0.0001*	0.0002*	0.0027*	0.6997	0.1137	0.0001*
Navajo	26	0.5657	0.6175	0.1144	0.2390	0.0114*	0.0028*	0.1186
Havasupai	8	0.5587	0.1799	0.7928	0.1986	0.1978	0.2994	0.7093
Mojave	2	0.4507	0.2000	0.5455	0.7255	0.0065*	0.4980	0.3072
White Mountain Apache	4	0.2646	0.8274	0.4768	0.5775	0.1969	0.0460*	0.8186
Pima	2	0.9103	0.4029	0.3454	0.3947	0.3158	0.7215	0.0684
Tohono O'odham	8	0.3231	0.0615	0.7709	0.4278	0.3190	0.3611	0.0349*
Mexico	26	0.0103*	0.0495*	0.0154*	0.0046*	0.0009*	0.0978	0.0001*
Control	22	0.0107*	0.0006*	0.9128	0.5393	0.2128	0.0007*	0.3792
Large [a]	30	0.6204	0.1656	0.6128	0.6926	0.0711	0.4563	0.4678
Other [b]	6	0.6429	0.0235*	0.1611	0.8440	0.0836	0.0017*	0.0739

*Significant at the 0.05 level

[a] Large included large-eared Hopi and Tohono O'odham landraces.

[b] Other included four landraces with sweet and pop endosperm

Table 12: continued

Ethnic group	Degrees of freedom	branch	spike	shank	branching	tassel	elength
Cochiti Pueblo	6	0.0855	0.9167	0.2070	0.8319	0.9884	0.5623
Santo Domingo Pueblo	6	0.4389	0.7611	0.6463	0.6990	0.6100	0.4488
San Felipe Pueblo	2	0.4519	0.5639	0.4793	0.9209	0.7388	0.0512*
Zia Pueblo	6	0.7267	0.6742	0.7094	0.1006	0.6141	0.1543
Acoma Pueblo	4	0.2415	0.2012	0.9046	0.5338	0.4598	0.7600
Laguna Pueblo	8	0.2988	0.2661	0.3335	0.3551	0.2016	0.4857
Isleta Pueblo	4	0.9032	0.3630	0.6557	0.6447	0.7136	0.9847
Taos Pueblo	4	0.5665	0.7445	0.6857	0.2380	0.8178	0.6783
Picuris Pueblo	2	0.2432	0.0146*	0.3631	0.2598	0.2079	0.3775
Tesuque Pueblo	4	0.2266	0.6645	0.2277	0.4654	0.7203	0.6259
Jemez Pueblo	4	0.1225	0.6564	0.8783	0.9485	0.6021	0.7930
Hopi	76	0.0920	0.7294	0.1582	0.0001*	0.2088	0.1405
Navajo	26	0.4675	0.0533*	0.6908	0.4391	0.5051	0.9231
Havasupai	8	0.2070	0.0032*	0.0161*	0.6367	0.0689	0.1189
Mojave	2	0.6049	0.3987	0.5637	0.4484	0.5157	0.0275*
White Mountain Apache	4	0.3230	0.4678	0.6397	0.0230*	0.1110	0.5292
Pima	2	0.3731	0.7673	0.0041*	0.7010	0.7399	0.4869
Tohono O'odham	8	0.9995	0.4443	0.1843	0.0584	0.1659	0.5940
Mexico	26	0.3285	0.1277	0.0392*	0.2250	0.3819	0.4405
Control	22	0.0059*	0.5760	0.2492	0.0010*	0.5683	0.6091
Large [a]	30	0.6855	0.0022*	0.0306*	0.0536*	0.0386*	0.0523*
Other [b]	6	0.3590	0.5898	0.3088	0.0105*	0.0168*	0.4188

Table 12: continued

Ethnic group	Degrees of freedom	eweight	weightear	cobeardia	kv	k10	rachisseg
Cochiti Pueblo	6	0.3194	0.3109	0.4068	0.0114*	0.0088*	0.2855
Santo Domingo Pueblo	6	0.3970	0.4648	0.7700	0.4488	0.4866	0.6180
San Felipe Pueblo	2	0.4550	0.4800	0.3227	0.7127	0.5322	0.1102
Zia Pueblo	6	0.1736	0.1367	0.4756	0.5924	0.4115	0.8119
Acoma Pueblo	4	0.6650	0.6765	0.7991	0.8585	0.7996	0.5707
Laguna Pueblo	8	0.4320	0.9447	0.8759	0.7683	0.9048	0.9650
Isleta Pueblo	4	0.6837	0.3938	0.3463	0.5029	0.6674	0.1951
Taos Pueblo	4	0.0508*	0.0519*	0.5795	0.6596	0.7543	0.4098
Picuris Pueblo	2	0.3522	0.4492	0.5247	0.5537	0.9145	0.5373
Tesuque Pueblo	4	0.5446	0.5754	0.8330	0.5522	0.3359	0.9573
Jemez Pueblo	4	0.3027	0.0914	0.1054	0.0098*	0.2236	0.8536
Hopi	76	0.0099*	0.0194*	0.3526	0.0001*	0.0002*	0.2343
Navajo	26	0.0942	0.0396*	0.7796	0.0933	0.0642	0.4959
Havasupai	8	0.1356	0.0269*	0.5370	0.0052*	0.0196*	0.5123
Mojave	2	0.1374	0.1474	0.0701	0.4527	0.6902	0.3495
White Mountain Apache	4	0.3750	0.5108	0.8973	0.9375	0.9396	0.2897
Pima	2	0.4084	0.603	0.4611	0.7004	0.9057	0.4938
Tohono O'odham	8	0.8563	0.5691	0.1300	0.3052	0.6977	0.1862
Mexico	26	0.2407	0.0828	0.0953	0.7106	0.7968	0.0422*
Control	22	0.0240*	0.0125*	0.5414	0.1263	0.2791	0.4079
Large [a]	30	0.0599	0.1425	0.3034	0.4318	0.1341	0.0026*
Other [b]	6	0.8311	0.9127	0.8578	0.1907	0.1969	0.7517

Principal Component Analysis

In the combined analysis, using accession means across all environments, the first principal component explained 43% of the variation (Table 13). Seven principal components had eigenvalues greater than one, and explained 88% of the variation in the data. The first component was most strongly correlated with plant height and ear diameter, though most variables were well correlated with this component (Table 15). The second component was strongly correlated to variables that describe ear length and yield.

Table 13: Eigenvalues from the principal component analysis using the accession mean across all environments

Principal component	Eigenvalue	Proportion (%)	Cumulative (%)
1	18.14	0.43	0.43
2	5.31	0.13	0.56
3	4.40	0.10	0.66
4	3.35	0.08	0.74
5	2.50	0.06	0.80
6	2.06	0.05	0.85
7	1.15	0.05	0.88

In the New Mexico analysis, using accession means across only the New Mexico environments, there were eight principal components with an eigenvalue of greater than one, that explained 90% of the variation in the data (Table 14). The first two components were represented by most variables and explained 55% of the variation. The most strongly correlated variables in the first component were plant traits and ear diameter (Table 16). The second component was correlated strongly to ear length, tassel spike length and yield variables. Results were similar to those of the combined analysis using accession means across all locations.

The first two principal components were graphed in order to visualize possible clusters. In the combined analysis, one group of landraces was separated with positive values for principal component one and negative values for principal component two (Figure 6). This group included Tohono O'odham and Hopi landraces, and control landraces and

Table 14: Eigenvalues from the principal component analysis using accession means across New Mexico environments

Principal component	Eigenvalue	Proportion (%)	Cumulative (%)
1	17.19	0.40	0.40
2	6.81	0.16	0.56
3	4.20	0.10	0.66
4	3.36	0.08	0.73
5	2.48	0.06	0.79
6	2.14	0.05	0.84
7	1.28	0.03	0.87
8	1.03	0.02	0.90

hybrids. The Keresan Pueblo and Jemez landraces were primarily on one extreme with positive numbers for both principal components. On the other extreme were the Tohono O'odham, Pima, and River Yuman landraces, with negative values for both principal components. The northern Tiwa Pueblo landraces, Picuris and Taos, were intermediate and the Tesuque landraces were scattered throughout the middle. Navajo, Apache, and Hopi landraces were also scattered. The landraces with pop and sweet endosperm had more negative values for the second principal component than the Pueblo and Hopi ethnic groups that they belong to. Three Mexican landraces were set apart with very negative values for principal component two.

Accessions with a higher value for principal component one tend to have larger plants and wider ears. Accessions with a higher value for principal component two tend to have longer ears and larger kernels. The Keresan Pueblo landraces have large plants, wide ears, and long ears. The Tohono O'odham, Pima and River Yuman landraces have smaller plants and smaller ears. The group of Hopi and Tohono O'odham landraces that are set apart have large plants and wide, short ears. The New Mexico analysis had a similar continuum of accessions with a similar interpretation of the principal components (Figure 7).

To better visualize the relationships between the cultural groups, means were calculated for the landraces in each ethnic group. Hopi and Tohono O'odham landraces were split into two groups with large-eared landraces separated from those with small ears. Mexican landraces were split according to their assigned races (GRIN). Controls were separated individually, except for the two hybrids and the four Midwestern populations that

Table 15: Eigenvectors for the first seven components from the combined analysis using accession means across all environments

Variable	1	2	3	4	5	6	7
GDD5a	0.17	-0.13	0.18	0.12	0.11	0.20	0.19
GDD5s	0.16	-0.14	0.20	0.13	0.09	0.20	0.19
tiller	-0.17	0.12	0.11	-0.09	0.08	0.00	0.31
height	0.20	-0.08	0.12	0.07	-0.07	0.15	-0.15
earheight	0.19	-0.15	0.11	0.10	-0.03	0.18	-0.11
leaves	0.21	-0.13	0.06	0.09	-0.03	0.09	-0.10
nodes	0.19	-0.18	0.06	0.11	-0.04	0.16	-0.10
llength	0.13	0.16	0.25	-0.06	0.10	0.05	0.32
circ	0.17	0.14	0.03	0.00	0.24	-0.04	0.17
lwidthcm	0.22	-0.01	0.01	0.01	-0.07	0.09	-0.01
larea	0.21	0.08	0.13	-0.02	0.02	0.08	0.14
plantear	-0.17	0.12	-0.13	-0.07	0.13	-0.19	-0.01
GDDleafnum5	-0.15	0.03	0.14	0.02	0.20	0.11	0.46
branch	0.17	-0.01	0.12	0.07	0.07	-0.26	0.09
branching	0.19	0.01	0.16	0.13	-0.04	-0.22	0.11
spike	0.05	0.16	0.14	-0.17	-0.07	0.46	-0.07
tassel	0.15	0.10	0.22	-0.03	-0.20	0.03	-0.05
branchtass	0.16	-0.05	0.09	0.20	0.08	-0.32	0.20
spiketass	-0.12	0.06	-0.10	-0.16	0.13	0.45	-0.03
husk	0.14	0.04	0.09	0.01	0.17	-0.20	-0.26
shank	0.10	0.16	0.18	0.03	-0.17	-0.09	-0.23
row	0.15	0.02	-0.01	-0.35	0.22	-0.03	-0.05
kernels	0.16	0.17	0.11	-0.19	-0.18	-0.13	0.00
elength	0.09	0.34	0.15	-0.08	-0.13	-0.06	-0.01
dia12	0.20	0.06	-0.20	-0.04	0.13	0.03	0.01
dialength	0.09	-0.22	-0.28	0.04	0.23	0.06	0.05
cobeardia	-0.02	0.09	0.20	0.22	0.32	0.03	-0.35
kthick	-0.12	0.32	0.04	0.15	0.07	0.10	-0.05
kwidth	0.04	0.16	-0.21	0.41	-0.10	0.08	0.09
klength	0.19	0.01	-0.24	-0.09	-0.06	0.07	0.11
kwidthlength	-0.14	0.08	0.06	0.40	-0.03	0.00	-0.03
kthicklength	-0.18	0.14	0.18	0.15	0.08	0.02	-0.11
kthickwidth	-0.13	0.13	0.22	-0.21	0.13	0.02	-0.11
eweight	0.19	0.19	-0.08	-0.13	-0.07	-0.04	-0.02
weightear	0.19	0.19	-0.09	-0.16	-0.07	-0.03	0.01
kv	0.07	0.27	-0.25	0.21	-0.11	0.10	0.11
k10	0.08	0.24	-0.25	0.20	-0.18	0.10	0.05
cobdia	0.19	0.10	-0.13	0.03	0.24	0.04	-0.12
cobc	0.05	0.06	-0.09	-0.12	-0.27	-0.07	0.12
rachis	0.18	0.12	-0.16	0.03	0.27	-0.02	-0.08
pith	0.14	0.17	-0.15	-0.02	0.35	-0.07	-0.05
rachissegavg	-0.11	0.32	0.06	0.12	0.08	0.07	-0.03

Table 16: Eigenvectors for the first eight principal components from the New Mexico analysis using accession means across New Mexico environments

Variable	1	2	3	4	5	6	7	8
GDD5a	0.17	-0.14	0.16	0.13	0.06	0.22	0.16	0.06
GDD5s	0.16	-0.15	0.18	0.14	0.06	0.22	0.17	0.08
tiller	-0.16	0.14	0.11	-0.04	0.09	-0.01	0.33	-0.07
height	0.21	-0.07	0.11	0.06	-0.05	0.17	-0.14	-0.05
earheight	0.20	-0.14	0.09	0.07	-0.02	0.18	-0.11	-0.07
leaves	0.22	-0.12	0.05	0.06	-0.05	0.08	-0.10	-0.08
nodes	0.20	-0.17	0.04	0.07	-0.05	0.15	-0.12	-0.11
llength	0.13	0.19	0.23	0.02	0.08	0.07	0.26	-0.06
circ	0.17	0.17	0.04	0.05	0.18	-0.06	0.23	-0.07
lwidthcm	0.22	0.00	0.00	0.01	-0.04	0.09	-0.04	-0.11
larea	0.21	0.10	0.12	0.02	0.03	0.10	0.11	-0.11
plantear	-0.17	0.13	-0.11	-0.04	0.11	-0.20	0.05	0.10
GDDleafnum5	-0.09	-0.04	0.20	0.14	0.16	0.21	0.49	0.29
branch	0.16	0.01	0.11	0.12	0.04	-0.30	0.05	-0.05
branching	0.18	0.03	0.17	0.15	-0.11	-0.22	0.06	0.10
spike	0.02	0.21	0.08	-0.17	0.01	0.42	-0.07	0.02
tassel	0.13	0.16	0.20	-0.03	-0.18	0.05	-0.08	0.20
branchtass	0.16	-0.06	0.10	0.23	-0.02	-0.31	0.14	0.01
spiketass	-0.12	0.06	-0.13	-0.16	0.18	0.39	-0.02	-0.17
blades	0.15	-0.20	-0.13	-0.03	-0.05	0.14	-0.13	0.16
husk	0.14	0.05	0.12	0.06	0.16	-0.19	-0.12	-0.27
shank	0.08	0.20	0.16	0.06	-0.12	-0.02	-0.14	0.04
row	0.15	0.06	0.04	-0.31	0.26	-0.07	-0.01	0.05
kernels	0.15	0.18	0.14	-0.15	-0.19	-0.07	-0.06	-0.03
elength	0.07	0.32	0.14	-0.03	-0.14	-0.01	-0.09	-0.05
dia12	0.21	0.06	-0.19	-0.05	0.14	-0.01	0.03	0.04
dialength	0.10	-0.22	-0.26	0.00	0.24	-0.01	0.12	0.04
cobeardia	-0.03	-0.02	0.12	0.28	0.32	0.05	-0.41	0.30
kthick	-0.11	0.28	-0.01	0.18	0.08	0.11	-0.06	-0.02
kwidth	0.03	0.10	-0.28	0.38	-0.14	0.09	0.07	-0.08
klength	0.19	0.02	-0.23	-0.12	-0.05	0.04	0.17	-0.05
kwidthlength	-0.14	0.03	-0.02	0.41	-0.08	0.02	-0.09	0.01
kthicklength	-0.19	0.12	0.13	0.19	0.08	0.05	-0.15	0.05
kthickwidth	-0.13	0.15	0.24	-0.15	0.18	0.04	-0.11	0.06
eweight	0.19	0.20	-0.07	-0.12	-0.06	-0.02	-0.04	0.04
weightear	0.18	0.20	-0.07	-0.14	-0.08	-0.02	-0.01	0.04
kv	0.06	0.23	-0.28	0.19	-0.11	0.10	0.11	-0.04
k10	0.06	0.21	-0.30	0.17	-0.18	0.09	0.05	0.01
cobdia	0.19	0.06	-0.15	0.06	0.26	0.01	-0.13	0.13
cobc	0.05	0.03	-0.09	-0.12	-0.26	-0.01	0.06	0.70
rachis	0.18	0.10	-0.16	0.05	0.27	-0.05	-0.09	0.13
pith	0.14	0.15	-0.14	0.02	0.36	-0.10	-0.03	0.10
rachisseg	-0.09	0.29	0.01	0.15	0.08	0.08	-0.04	-0.03

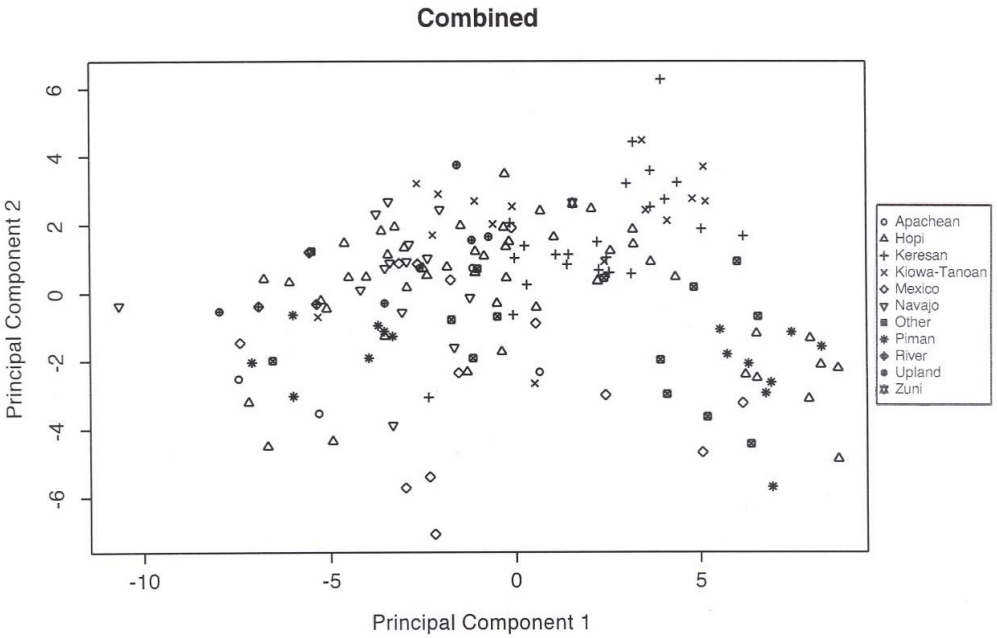

Figure 6: The first two principal components from the combined analysis using accession means across all environments

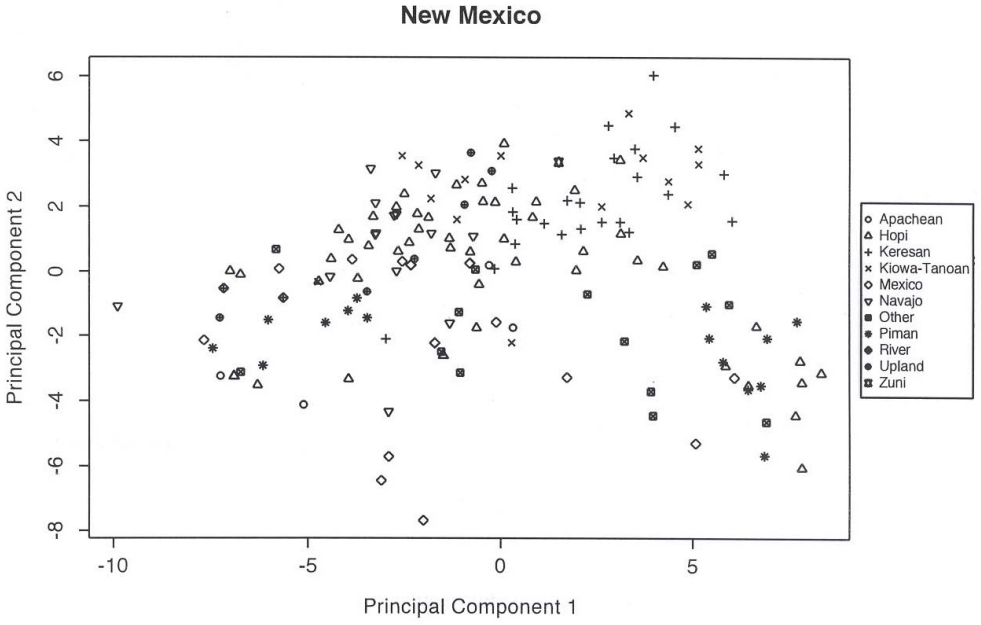

Figure 7: The first two principal components from the New Mexico analysis using accession means across the New Mexico environments

were grouped together. The landraces with different endosperm types were separated from other landraces in the same ethnic group, and included an Acoma popcorn, a Tesuque sweet corn and three Hopi sweet corns.

In the combined analysis, the large-eared Hopi and Tohono O'odham landraces formed a distinct group that also included Gourdseed, Mexican June, the Arizona germplasm material, and the Mexican *Tuxpeno Norteno* (GRIN) landrace (Figure 4). The Mexican landraces assigned to *Chapalote* and *Reventador* (GRIN) were also in a distinct group. The rest of the accessions laid on a continuum. On one extreme were the Keresan, Towa, Tewa, and southern Tiwa landraces. The cornbelt accessions also fell near this extreme. In the middle were the northern Tiwa, Havasupai, Tewa, Hopi, and Navajo landraces. Near this group was the White Mountain Apache landrace and several Mexican landraces including *Dulcillo de Noreste* (GRIN). At the other extreme were the Walapai, Mojave, Pima-Maricopa, and Tohono O'odham landraces. The Mexican landraces assigned as *Apachito*, *Cristalino de Chihuahua*, and *Gordo* (GRIN) were also at this extreme. The graph using New Mexico data showed similar relationships, with the separation of the large-eared Hopi and Tohono O'odham landraces and the continuum of Pueblo to Piman landraces (Figure 5).

Clustering

Clustering was done for both the combined analysis using data from three environments (IA 2004, NM 2004, NM 2005), and for the New Mexico analysis, using data from the NM 2004 and NM 2005 environments. The analysis of the cluster dendograms showed five large clusters for both analyses and several smaller clusters with less than five accessions each. The order of the accessions on the cluster dendograms and the accessions belonging in each cluster are identified in Appendix Tables 23 and 24.

There were five large clusters and ten small clusters in the combined cluster analysis (Figure 10). The pueblo cluster included Keresan, Tewa, Southern Tiwa and Towa Pueblos, Zuni, and Hopi landraces. The cornbelt cluster included cornbelt landraces and hybrids, Hopi, one San Felipe, one White Mountain Apache, and Mexican June landraces. The southern dent cluster included Hopi, Tohono O'odham and Gourdseed landraces and the Arizona germplasm material. The northern cluster included Tewa, northern Tiwa, the

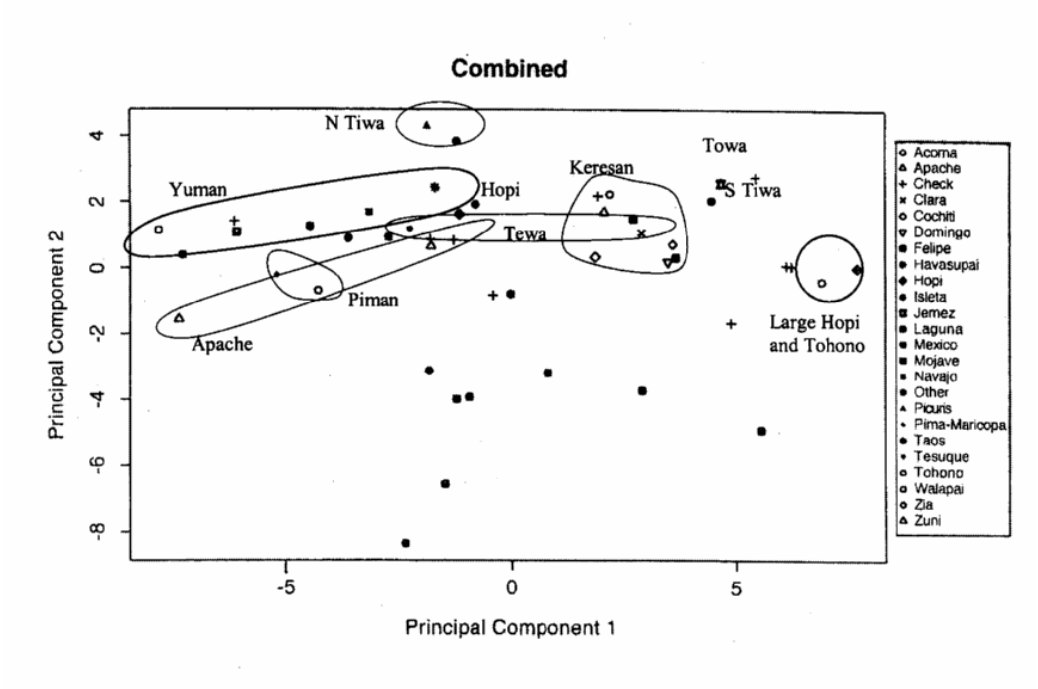

Figure 8: The first two principal components from the combined analysis using ethnic group means across all environments

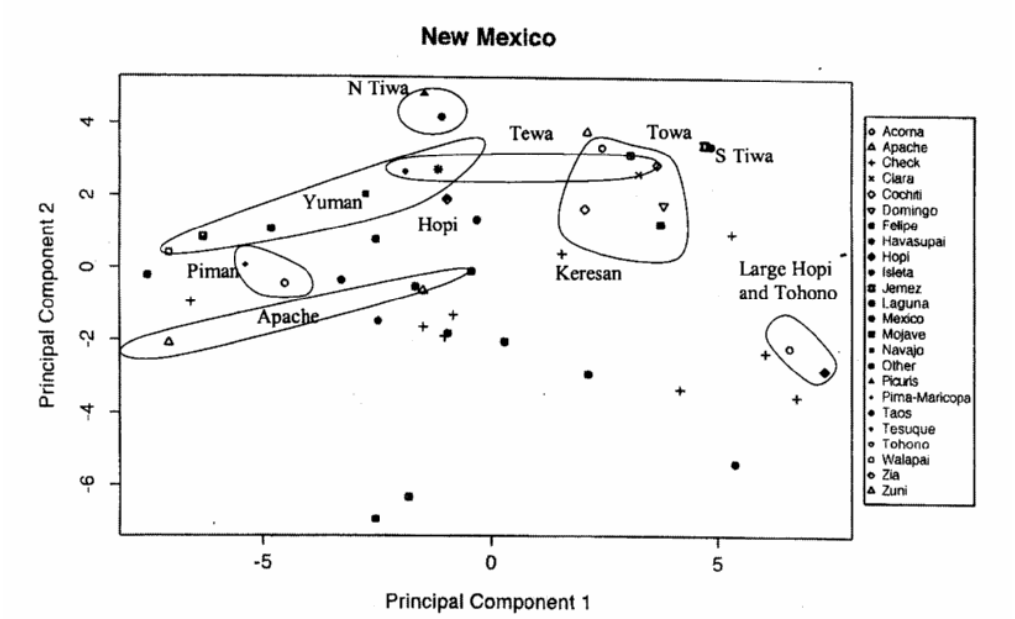

Figure 9: The first two principal components from the New Mexico analysis using ethnic group means across New Mexico environments

unknown Pueblo, Havasupai, Navajo, Hopi and a White Mountain Apache landrace. The

papago cluster included Tohono O'odham, Pima-Maricopa, Mojave, Chihuahua, Hopi, Mesquakie, and the San Carlos Apache landraces.

The small clusters included mostly controls and Mexican landraces, with separate clusters for landraces with sweet and pop endosperm. The sweet corn cluster included three Hopi landraces and a White Mountain Apache landrace. Two landraces clustered by themselves, a Navajo landrace and the Acoma popcorn. Another Navajo landrace clustered with the Walapai landrace. The Chapalote cluster included three Mexican landraces similar to Chapalote. The Sonora cluster included three Mexican landraces from Sonora. Two other Mexican landraces clustered together. The control Quapaw and a Mexican landrace formed one cluster, and the controls Arapaho and Cherokee formed another cluster.

In the New Mexico analysis there were five large clusters and nine small clusters (Figure 11). The large clusters were very similar to the ones in the combined analysis. The pueblo cluster included Keresan, Tewa, Southern Tiwa, Towa, Zuni, Havasupai and Navajo landraces. The northern cluster included northern Tiwa, Tewa, Havasupai, Navajo, Hopi and the unknown Pueblo landraces. The papago cluster included Tohono O'odham, Hopi, Pima, Mojave, Walapai, and Chihuahua landraces. The cornbelt cluster included cornbelt landraces and hybrids, Hopi, a San Felipe, and a White Mountain Apache landraces. The southern dent cluster included Hopi, Tohono O'odham, Mexican, Mexican June and Gourdseed landraces and the Arizona germplasm material.

The small clusters included mostly controls and Mexican landraces and separate clusters for landraces with sweet and pop endosperm. The sweet cluster included three Hopi landraces. The Acoma popcorn was clustered with a Cochiti landrace. Three landraces clustered by themselves, two Navajo and Longfellow Flint. The Chapalote cluster included three Chapalote like Mexican landraces. The Sonora cluster included three Mexican landraces from Sonora and a White Mountain Apache landrace. Two other Apache landraces clustered with Mesquakie. Three controls, Arapaho, Cherokee, and Quapaw clustered with a Mexican landrace.

Most of the accessions clustered into similar clusters, whether from the combined or the New Mexico analysis, with 23 accessions that clustered differently (Table 17). These included two Havasupai, seven Hopi, two White Mountain Apache, one San Carlos Apache,

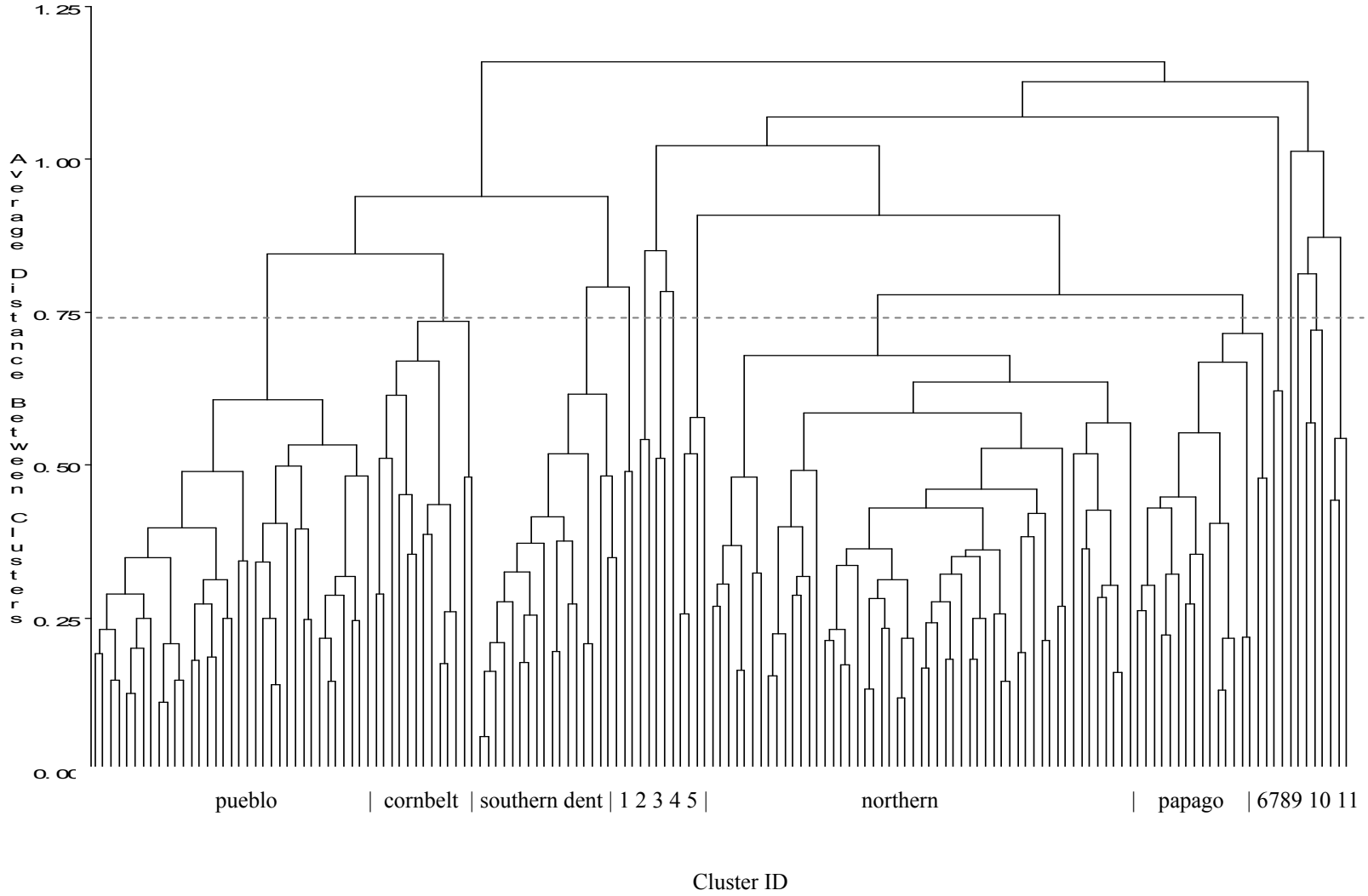

Figure 10: Cluster dendogram for the combined analysis using data from all three environments with 15 clusters identified

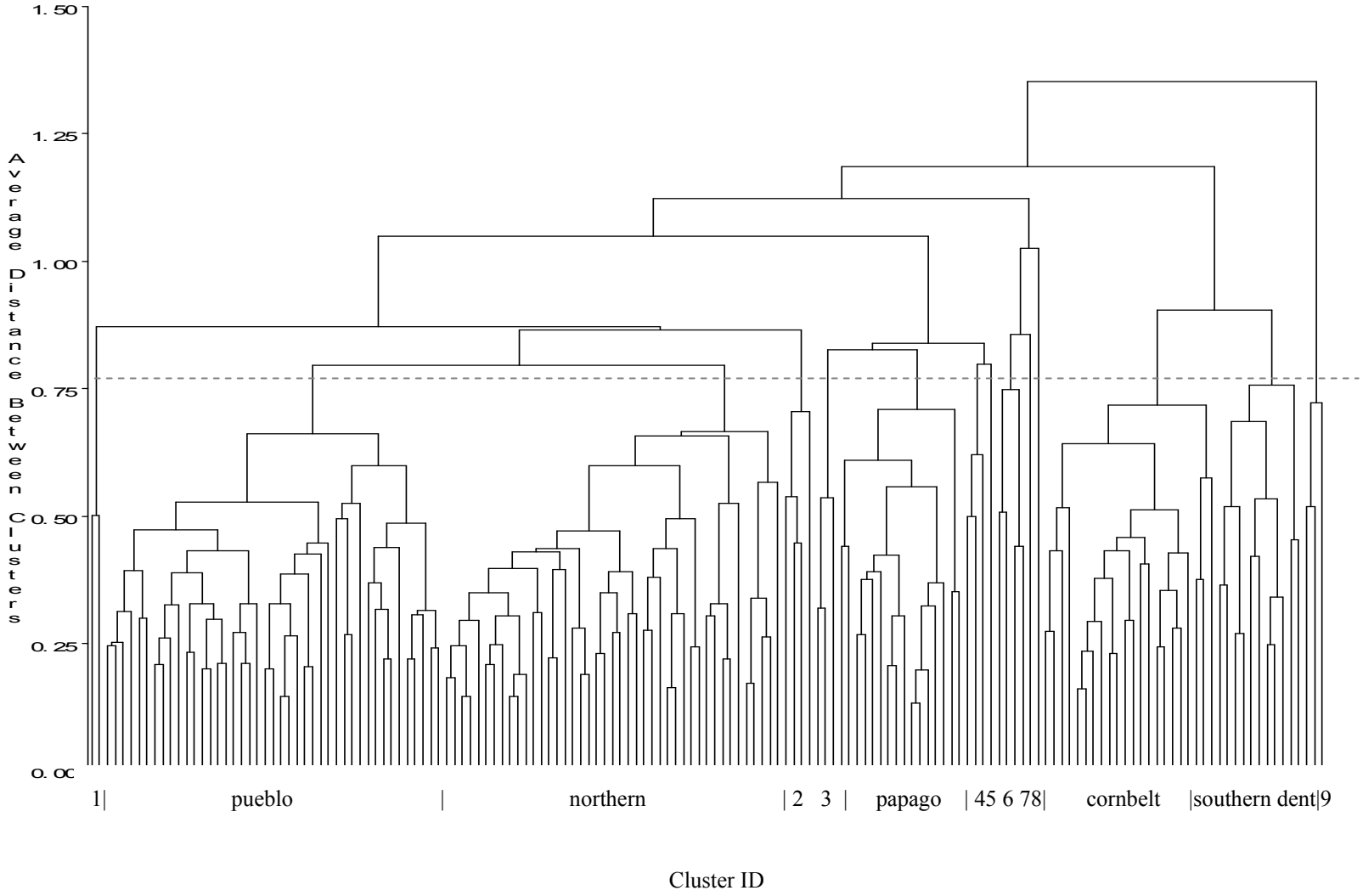

Figure 11: Cluster dendogram for the New Mexico analysis using data from the two New Mexico environments with 14 clusters identified

three Mexican, five controls, one Cochiti, one Navajo, and one Walapai landraces. The Havasupai, Navajo, and six of the Hopi landraces changed from the northern group to the pueblo group. Mexican June and a Hopi landrace both changed from the cornbelt group to the southern dent group. Two of the Mexican accessions that were in their own cluster were joined to the southern dent group. Some of the controls that were located in two separate clusters in the combined analysis were joined in the same cluster in the New Mexico analysis.

Both cluster analyses separated the Pueblo and southern Arizona landraces, with an intermediate group of landraces. In addition, the large-eared Hopi and Tohono O'odham landraces were separated, as were the cornbelt landraces and hybrids. The placement of individual accessions varies a little between the two analyses, though the primary groups were all present in both analyses. The cluster analysis also agrees with the continuum found in the principal component analysis.

The differences between the clustering in the two analyses may be due to the environmental interactions found in the analysis of variance. The Hopi, Mexico and control groups had many variables with a significant accession by environment interaction, and some landraces from these groups clustered differently between the two analyses. However, the effect of the interactions on the clustering cannot be determined, since the clustering is based on correlations. While the differences between the two analyses are important, both analyses lead to the same general conclusions.

Morphology of Clusters

There are differences in the morphology of landraces belonging to the five large clusters (Table 18). Landraces in the pueblo cluster were later to flowering, had many tillers and tall, thick plants, with many tassel branches, long ears and big kernels. The landraces in the papago cluster were earlier flowering, had many tillers and short, thin plants, with few tassel branches, short ears and small kernels. The northern cluster landraces had intermediate traits between the papago and pueblo cluster traits. The southern dent cluster landraces were similar to the pueblo cluster except they had fewer tillers, and wider, shorter ears. The cornbelt cluster had similar traits to the northern and pueblo clusters.

Table 17: Accessions that clustered differently in the New Mexico vs. the combined analysis

Accession	Ethnic group	New Mexico analysis [a]	Combined analysis [a]
PI 317674	Havasupai	pueblo	northern
PI 317679	Havasupai	pueblo	northern
NSL 67056	Hopi	pueblo	northern
NSL 67060	Hopi	pueblo	northern
NSL 67061	Hopi	pueblo	northern
NSL 68326	Hopi	pueblo	northern
PI 503565	Hopi	pueblo	northern
PI 218175	Hopi	pueblo	northern
PI 503568	Navajo	pueblo	northern
PI 218145	Cochiti Pueblo	Acoma Pueblo popcorn	pueblo
PI 213728	White Mountain Apache	cornbelt	cornbelt
PI 213729	White Mountain Apache	Sonora	northern
PI 213730	White Mountain Apache	with PI 217411 and PI 213736	sweet
PI 213736	San Carlos Apache	with PI 217411 and PI 213730	papago
PI 217411	Mesquakie	with PI 213736 and PI 213730	papago
NSL 67052	Hopi	southern dent	cornbelt
PI 311243	Mexican June	southern dent	cornbelt
PI 420252	Mexico	southern dent	with PI 629147
PI 629147	Mexico	southern dent	with PI 420252
PI 213741	Walapai	papago	with PI 222285
NSL 2830	Mexico	native controls	with PI 213757
PI 213732	Arapaho	native controls	with NSL 6048
Ames 6048	Cherokee	native controls	with PI 213732
PI 213757	Quapaw	native controls	with NSL 2830

[a] Primary ethnic groups in clusters:

pueblo-Keresan, Hopi
northern-Tanoan, Hopi, Navajo, Havasupai
papago-Tohono O'odham, Pima, Mojave, Walapai, Mexico, Hopi
cornbelt-Controls, Hopi
southern dent-Hopi, Tohono O'odham, Arizona germplasm
sonora-three Mexican landraces from Sonora
chapalote- three Mexican landraces
native controls- Arapaho, Cherokee, Quapaw and one Mexican landrace

Table 18: Variable means for the landraces in the five large clusters in the combined analysis using racial means across environments

Variable	Cluster mean				
	pueblo	northern	southern dent	papago	cornbelt
GDD5a	1513	1375	1766	1295	1483
GDD5s	1589	1451	1832	1384	1549
tiller	3.37	3.97	1.05	4.03	1.73
shootmain	2.18	2.08	2.39	2.21	2.43
shoottiller	1.26	1.73	0.80	2.04	0.67
height	202.26	141.94	252.99	156.07	202.22
earheight	93.89	55.24	159.06	64.97	104.95
leaves	16.18	13.97	19.70	13.63	17.55
nodes	9.87	8.27	13.71	8.74	11.24
llength	101.20	88.91	92.67	76.40	85.25
circ	84.52	77.76	87.45	63.95	76.87
lwidth	99.03	85.14	112.66	82.59	105.89
lwidthcm	9.90	8.51	11.27	8.26	10.59
larea	753.31	571.74	787.38	476.89	678.91
plantear	2.26	2.81	1.62	2.62	2.00
plantearnum	12.98	10.79	13.18	12.25	11.99
GDDleafnum5	100.53	107.76	93.94	105.05	89.42
branch	18.45	15.08	19.71	11.47	17.58
spike	28.95	27.25	27.77	28.43	28.16
branching	16.50	13.36	17.67	10.21	16.10
tassel	50.06	44.32	48.58	43.22	49.25
branchtass	0.33	0.30	0.37	0.23	0.33
spiketass	0.58	0.62	0.57	0.67	0.58
husk	13.41	11.85	13.69	9.70	11.35
shank	15.34	12.41	12.50	11.15	13.54
row	15.14	13.45	15.52	11.90	15.14
kernels	44.26	36.54	39.06	32.72	43.43
elength	24.41	20.50	19.04	18.89	21.47
diabutt	43.94	39.73	48.85	32.94	45.89
dia14	44.99	41.66	51.43	36.02	48.69
dia12	42.82	39.85	49.73	34.79	47.22
dia34	39.95	37.08	46.65	32.34	44.40
eweight	211.89	146.57	201.19	107.36	238.08
dialength	0.18	0.20	0.27	0.19	0.23
cobeardia	0.66	0.65	0.65	0.64	0.61
conical	3.09	3.32	3.86	2.99	3.04
kthick	46.73	47.50	39.53	47.79	41.18
kwidth	86.89	88.57	90.60	87.15	89.63

Table 18: continued

Variable	Cluster mean				
	pueblo	northern	southern dent	papago	cornbelt
klength	106.71	101.86	123.26	96.88	124.85
kwidthlength	0.82	0.88	0.74	0.91	0.73
kthicklength	0.44	0.47	0.33	0.50	0.34
kthickwidth	0.54	0.54	0.44	0.55	0.47
kw	26.54	26.15	26.95	24.79	31.10
kv	24.03	23.53	23.52	22.06	26.29
weightear	168.13	121.42	158.73	90.46	194.43
k10	27.39	27.08	27.63	25.72	31.73
cobdia	28.11	25.85	32.08	22.08	28.70
cobc	1.28	1.20	1.08	1.09	1.69
rachis	18.15	16.74	20.69	12.70	18.45
pith	10.21	9.64	11.03	6.40	9.56
rachisseg	4.44	4.50	3.74	4.49	3.91

Relationship of Midwestern controls with Southwestern landraces

The Midwestern controls grouped into approximately four groups in the principal component and cluster analysis. The Arizona germplasm material, Gourdseed and, in the New Mexico analysis, Mexican June, grouped with the large-eared Hopi and Tohono O'odham landraces. Several of these landraces belong to *Southeastern American Southern Dent* (GRIN). The two hybrids and three landraces (*Cornbelt)* clustered together and were near the southern dent and pueblo cluster. The proximity of these cornbelt dents to the Keresan Pueblo landraces may indicate that these Pueblo landraces have been affected by maize from the Midwest. A Keresan Pueblo landrace from the Santo Domingo Pueblo is known to be a mix of native landraces with cornbelt dents (GRIN). Three of the Midwestern Native American landraces were in a separate cluster and grouped near intermediate landraces in the principal component analysis. Two of these landraces belong to *Southeastern American 8-row*. The other Midwest Native American landrace, Mesquakie (*Northeastern North American Flint and Flour*), grouped with the southern Arizona landraces. One other Midwestern population clustered by itself.

Many of these landraces are assigned to a race in GRIN and cluster well based on these racial designations. The proximity of the controls in the cluster analysis to various

Southwestern landraces indicates a relationship between Midwestern and Southwestern maize. Southwestern landraces may have been influenced by introductions of Midwestern maize, they may have similar parentage, or similarities could have developed independently.

Relationships of Mexican and Southwestern landraces

The Mexican landraces were separated into five groups by the cluster analysis, consistent with geographic relationships and previous racial relationships determined by Sanchez G. (1989). Many of these Mexican landraces have been assigned to a race in GRIN. Races are indicated by italics, with landraces in normal text. These Mexican races have been described by Wellhausen et al. (1952), Hernandez and Alanis (1970) and Sanchez G. (1989).

Coahuila 21 (*Tuxpeno Norteno*) and Onaveno clustered with landraces classified as *Southeastern American Southern Dent* (GRIN) in the New Mexico analysis, and by themselves in the combined analysis. Tuxpeno Norteno was clustered separately by Sanchez G. (1989) and is a progenitor of the Southern Dents. These two Mexican landraces may both be part of the race *Tuxpeno Norteno.*

Dulcillo del Noroeste (*Dulcillo de Noroeste*), Z01-005, and Z08-003 were in the northern cluster in the New Mexico analysis. In the combined analysis they clustered by themselves but near the cluster including landraces similar to *Chapalote*. All of these accessions are from Sonora, though Dulcillo del Noroeste is distinguished by a sweet endosperm. In Sanchez G.'s (1989) study Dulcillo de Noreste clustered with Chapalote. This relationship is confirmed in the combined analysis. However, the New Mexico analysis indicates that these Mexican landraces are similar to some of the intermediate Southwestern landraces.

Chapalote (*Chapalote*), Sinaloa 2 (*Chapalote*), and Nayarit 15 (*Reventador*) grouped with each other. These landraces are all from central Mexico. Sanchez G. (1989) classified Chapalote with Dulcillo de Noreste and Reventador with Longfellow Flint. However, Reventador is thought to have come from Chapalote and be similar to Dulcillo de Noreste (Wellhausen, 1952). These landraces clustered separately in both the principal component and cluster analysis, which may be due to their pop endosperm and small ears.

Chihuahua 138 (*Apachito*), Chihuahua 220 (*Cristalino de Chihuahua*), Chihuahua 128 (*Cristalino de Chihuahua*), and Chihuahua 160 (*Gordo*) grouped in the papago cluster. These landraces are from high elevations in Chihuahua. Apachito, Cristalino de Chihuahua, and Gordo were also grouped together by Sanchez G. (1989). These landraces are geographically close to the southern Arizona landraces, which may account for their morphological similarities.

Harinoso de Ocho clustered with several landraces native to the Midwest. Two of these landraces are assigned to *Southeastern American 8-row* (GRIN). Harinoso de Ocho may be a progenitor of maize that moved into the Midwest United States.

Some of the Mexican landraces cluster near Southwestern landraces, which may provide evidence of connections between Mexican and Southwest maize.

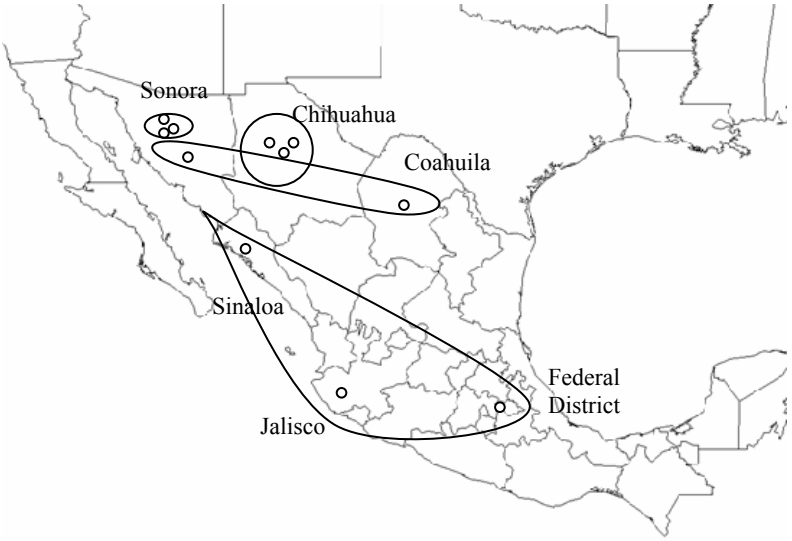

Figure 12: Location of Mexican landraces with clusters identified

Relationships with language groups

The relationships between landraces in the clustering correlate well with language groupings. The Keresan landraces grouped together, with a few exceptions. One San Felipe landrace, with dent endosperm, grouped with the cornbelt dents. The Acoma popcorn was separated in the combined analysis and grouped with a Cochiti landrace in the New Mexico analysis. This Cochiti landrace has a smaller ear diameter, smaller kernels, and lower ear weight than the other Cochiti landraces, though it is not a popcorn like the Acoma landrace.

The Tanoan landraces grouped near each other, though they did not necessarily group into their language subgroups. The larger language family is more important in distinguishing the differences between landraces, because of the similarities between the subgroups. Jemez, Isleta, Santa Clara, and one Tesuque landrace grouped together. Another Tesuque landrace grouped with the northern Tiwa landraces, Taos and Picuris. Grouping differences within the Tesuque landraces is surprising, given that the Tesuque did not allow the planting of non-traditional crops as late as 1912 (Edelman and Ortiz, 1979). Some believe, however, that Tesuque was taken over by non-Puebloan people (Carter and Anderson, 1945), which may explain the diversity found in this study. The Pueblos have been found to have much diversity within ethnic groups, based on morphology and isozyme data, and this may also explain these results (Carter and Anderson, 1945, Doebley et al., 1983). The northern Tiwa landraces from Picuris and Taos were separated from the southern Tiwa, Isleta, geographically; the landraces from these groups may cluster more based on geography than by language group. The unknown Pueblo landrace grouped with the Tiwa and Tesuque landraces and may have been collected from one of these northern Tiwa ethnic groups.

The Yuman landraces did not cluster as well based on language groups. The Upper Yuman landraces were separated from each other, with Havasupai landraces near the Pueblo landraces and the Walapai landrace with a Navajo landrace, in the combined analysis, and with the Piman landraces in the New Mexico analysis. There is only one landrace representing the Walapai ethnic group, which may not be a representative sample of that group. Mojave landraces, part of the River Yuman language group, clustered with the Piman landraces, which may be due to the geographic proximity of these two groups.

Distribution of Navajo and Apache landraces was more scattered, which may have been influenced by the late arrival of these ethnic groups into the Southwest. Most of the Navajo landraces clustered with the Pueblo landraces, except Cudu and Defiance White, which were in their own clusters. Cudu has a smaller plant and ear than the other Navajo landraces and is assigned to the *Northeastern North American Flint and Flour* race (GRIN). It was in its own cluster in the combined analysis, though in the New Mexico analysis it was in the same large cluster as the southern Arizona landraces and another *Northeastern North American Flint and Flour* landrace (GRIN). It was collected prior to 1914 (GRIN), which is much earlier than any other landrace, which may reflect relative timing of maize introductions into the Southwest. Defiance White has a larger plant but smaller ear than the other Navajo landraces. It was part of a larger cluster that includes Mexican and popcorn landraces in the combined analysis, though in the New Mexico analysis it did not cluster near any other accessions. It may also be a result of influence by other sources outside the Southwest. The Apache landraces were very scattered, grouping in different clusters in the combined analysis, though in the New Mexico analysis two of them clustered together.

The Piman landraces, Pima and Tohono O'Odham, were grouped together, with the exception of the large-eared Tohono landraces. Many Hopi landraces, though in the same language family as the Piman, were closer to the Pueblo landraces. The Hopi and Piman languages, while in the same family, are in different language subgroups. This, in combination with the geographic distance between the two ethnic groups and varying microclimates, may have influenced the separate clustering of these landraces. However, the southern dent group includes both Hopi and Tohono O'odham landraces, though this is probably more a factor of recent introductions of maize into the Southwest than similarities in language.

The Hopi landraces were found to cluster near landraces of all the other ethnic groups, and do not cluster well based on language group. The Hopi landraces fell into six clusters with two primary groups. Large-eared Hopi landraces split into two groups with some grouped in the southern dent cluster with the *Southeastern American Southern Dents* (GRIN), and some grouped with the cornbelt dents. The other primary group represents smaller eared landraces. Some of these grouped with the Keresan Pueblo landraces, some with the northern Pueblo and Navajo landraces, and some with the southern Arizona Piman

landraces. Three Hopi landraces with sweet endosperm also grouped separately. While most of the Hopi landraces group similarly in the combined versus the New Mexico analyses, seven Hopi landraces cluster into different groups. These landraces switched from the northern cluster in the combined analysis to the pueblo cluster in the New Mexico analysis.

There are many possible reasons the Hopi landraces may not have all clustered together. The Hopi ethnic group had much greater representation in this study, with 49 landraces, potentially representing more variability than other groups. These landraces were also collected by several different collectors and at different times, though this does not seem to affect the clustering directly. The Hopi are known to be traditional and had limited contact with the Spanish (Ortiz, 1979). The diversity found in this study contradicts this.

Several Hopi and Tohono O'odham landraces clustered with Mexican June, Gourdseed and the Arizona germplasm material. Some of these landraces, including Mexican June and Gourdseed, are classified as *Southeastern American Southern Dent* (GRIN). The Arizona germplasm materials are mixes of Mexican June and native flour and dent landraces (GRIN). Mexican June is a relatively recent introduction into the Southwest and was first mentioned in an Arizona Agricultural Experiment Station Bulletin in 1909 (Day, 1972). The inclusion of Hopi and Tohono O'odham landraces in this group suggest that they have been affected by the introduction of Mexican June and/or similar maize into the Southwest. A study by Day (1972) examined Hopi and Tohono O'odham maize landraces and found a similar distinction between small-eared flour maize and the large-eared dent maize in Arizona, which agrees with the clustering found in this study.

Relationship with cultural groups

Some of the most important cultural factors that influence maize dispersal and development are cultural traditions, the relationships between different ethnic groups and the arrival of the Spanish. It is difficult to determine the effects of specific cultural factors on the diversity of the maize landraces. However, there are a few landraces that cluster well based on these factors. The Apache and Navajo landraces were more scattered than the landraces of other ethnic groups. These groups migrated into the Southwest later and adopted agriculture from neighboring groups, which could account for this variability. The good

relations between the Hopi and Havasupai could explain why the Havasupai landraces are more similar to the Hopi than to the neighboring Walapai landraces. Several of the Pueblo landraces, including Taos and Picuris, are somewhat separate from other Pueblo landraces. This may be a result of the strained relationships between these ethnic groups and the geographic isolation of these Pueblos (Ortiz, 1979).

All of the cultures in the Southwest have been affected by European migration, in different ways and at different times. However, many of the landraces were collected in the mid-1900's (GRIN). Changes in migration, exchange, etc. caused by the Spanish would have affected all the landraces in similar ways *if* there was cultural mixing of maize landraces. Cultural relationships are not strongly associated with the cluster patterns found.

Relationships with climate and agricultural methods

The landraces clustered relatively well based on geography and climate. The southern Arizona landraces from the Sonoran desert and Pueblo landraces from the Colorado Plateau were separate. The Zuni landrace grouped near the Pueblo landraces. The northern Tiwa landraces, Picuris and Taos, were somewhat isolated from the rest of the Pueblo landraces, which could be a reflection of their geographic isolation. The Navajo landraces grouped near the Pueblo landraces; both ethnic groups occupy similar environments. The Apache were a far-ranging group, and their landraces were scattered throughout the clusters. Havasupai and Walapai landraces were not grouped together even though both of these ethnic groups are located on the Colorado River in northern Arizona. The Walapai landrace was instead grouped with the Mojave and Tohono O'odham landraces of southern Arizona. This grouping does not agree with geographic and climatic regions, however there is only one Walapai landrace, which may not be representative of this ethnic group or cultural relationships may have influence this maize landrace.

Agricultural methods did not prove to be meaningful in understanding the cluster relationships found. Many groups used irrigation and the methods and importance of irrigation changed over time (Ortiz, 1979). Multiple methods of water harvesting were used within ethnic groups and while certain maize landraces may have been used under specific irrigation situations, this study is not able to make those associations. No relationship was

found between the contribution of agriculture to subsistence and the clustering relationships. The landraces did cluster based on growing season however, with the Tohono O'odham and Pima landraces from areas with a long growing season clustering separately from the Pueblo and Havasupai landraces from areas with a shorter growing season. This distinction between landraces may also be strongly influenced by cultural or language relationships because of the interdependence of these factors with geographic and climatic factors.

Racial designation comparison

Previous studies of Southwestern landraces have distinguished two primary racial groups, the *Pueblo* and *Pima-Papago*. This study confirms this distinction and found a third group of landraces that may be strongly influenced by *Southeastern American Southern Dent*. Extensive studies have been done on the relationships between the landraces of various ethnic groups in the Southwest. Carter and Anderson (1945) assigned racial designations by ethnic group. Doebley et al. (1983) and Adams et al. (2006) examined the relationships between landraces without assigning racial designations. Some racial assignments have also been made in GRIN.

This study confirms what Carter and Anderson (1945) found, with a continuum from Yuman and Piman landraces to Pueblo landraces. Differences occur in the relationships among the Pueblo groups. Carter and Anderson (1945) classified the Taos, Tesuque, Isleta and Jemez landraces as *Pueblo*, with the Keresan landraces as *Pueblo* and intermediate (Table 19). In this study, the Keresan landraces grouped in the pueblo cluster and Taos in the northern cluster, with the pueblo cluster similar to the *Pueblo* race and the northern cluster similar to the intermediate landraces identified by Carter and Anderson (1945). In the principal component analysis, the Keresan landraces were at the extreme end, with the Tanoan landraces more intermediate. The differences found with Carter and Anderson (1945) may be due to this study using a more extensive maize collection, the differences in methodology or that Carter and Anderson (1945) gave one classification to all landraces in an ethnic group. The landraces examined by Carter and Anderson (1945) were also not grown in one controlled experimental setting and this may have effected their results.

Table 19: Comparison of the racial assignment by Carter and Anderson (1945) with the cluster assignment from the combined analysis

Ethnic group	Carter and Anderson racial assignment	Werth cluster assignment
Tohono O'odham	*Pima-Papago*	papago, southern dent
Mojave	*Pima-Papago*	papago
Havasupai	*Pima-Papago* and Intermediate	northern
Hopi	Intermediate and *Puebloan*	pueblo, northern, cornbelt, southern dent
Zuni	Intermediate and *Puebloan*	pueblo
San Felipe Pueblo	Intermediate and *Puebloan*	pueblo, cornbelt
Acoma Pueblo	Intermediate and *Puebloan*	pueblo
Laguna Pueblo	Intermediate and *Puebloan*	pueblo
Cochiti Pueblo	Intermediate and *Puebloan*	pueblo
Taos Pueblo	*Puebloan*	northern
Tesuque Pueblo	*Puebloan*	pueblo, northern
Isleta Pueblo	*Puebloan*	pueblo
Jemez Pueblo	*Puebloan*	pueblo
Navajo	Intermediate and *Puebloan*	northern, other

There are two primary distinctions between Doebley's et al. (1983) analysis and that of this study. These differences are similar to those between Doebley et al. (1983) and Carter and Anderson (1945). The Hopi landraces are found to be more intermediate by this study and Carter and Anderson (1945), though Doebley et al. (1983) found them to be more extreme. Mojave landraces clustered with Tohono O'odham and northern Mexican landraces in this study, and in Carter and Anderson (1945), while in Doebley et al. (1983) they grouped with the Pueblo landraces. Mojave landraces are more morphologically similar to the *Pima-Papago* race, and this ethnic group is geographically closer to the southern Arizona tribes. Doebley et al. (1983) did suggest that Mojave maize may have been influenced by Pueblo tribes, based on isozyme data. Isozymes and morphology are not always correlated since morphology is strongly affected by selection, while isozymes are not under direct selection, and this may explain the differences between studies based on morphology and isozymes data (Doebley et al., 1989). Isozyme data may give a better analysis of the genetic relationships, though morphology may support better analysis of the impacts of geography and culture on the adaptation of landraces.

The southern dent cluster was not identified by either of the previous two studies. Some of these landraces are assigned as *Southeastern American Southern Dent* (GRIN). This cluster also included the controls Mexican June and Gourdseed. None of the landraces in this cluster were used by Doebley et al. (1983). Carter and Anderson (1945) may have used similar landraces, though it is not possible to determine what exact landraces they did use. This study used many more landraces then either of the previous studies, which may explain the existence of this cluster. A study done by Day (1972) found two groups of Hopi and Tohono O'odham landraces, with the larger-eared landraces being assigned to the Mexican June Complex, which compliments what was found in this study.

Adams et al. (2006) distinguished four alpha groups of landraces with large, medium, small and dent ears and 27 beta groups (Table 20a). The *Pueblo* and *Pima-Papago* distinction found in previous studies was confirmed. The pueblo, northern, papago and southern dent clusters from this study's analysis correlate with Adams' alpha groups of large, medium, small and dent ears, respectively. The beta groups were designated using endosperm type and kernel color (Table 20a). Many landraces did not group similarly in the two analyses (Table 20b). The northern and pueblo cluster include landraces from the large and medium alpha group. The papago cluster includes landraces from the medium and small alpha groups. These results may partially be attributed to differences in the methods and variables used. Adams et al. (2006) only used ear characteristics and visual assessment to assign landraces to groups. There is no relationship between the beta groups assigned by Adams et al. (2006) and the clustering. Endosperm type and kernel color were not used in this study, which may contribute to the lack of a relationship between the clustering in this study and the beta groups of Adams et al. (2006). These variables were not included in this study since they are more useful for indexing then for classification (Anderson, 1945).

Several of the Southwest landraces have been previously assigned to a race in GRIN (Appendix Table 21). The landraces assigned to the *Pima-Papago* race are confirmed by this study. They are all from the Tohono O'odham ethnic group and fit the racial definition, as initially described by Anderson and Cutler (1942). The landraces assigned to the *Pueblo* race are not confirmed by this study. In this study these Navajo and Hopi landraces were clustered with the Keresan Pueblo landraces and with the Picuris, Taos, Navajo and Havasupai landraces. Carter and Anderson (1945) classified Hopi landraces as *Pueblo* and

Table 20a: Morphological alpha-beta groups from Adams et al. (2006) [a]

Alpha-beta group	Ear size category	Shank size category	Main kernel color and endosperm description
1-1	Large	Large	Blue flour
1-2	Large	Large	White or white and red flour
1-3	Large	Large	Orange flour
1-4	Large	Large	Mixed color flour
1-5	Large	Large	Mixed color flour or flint
2-6	Small	Small	White flour
2-7	Small	Small	White flint or flour
2-8	Small	Small	White sweet
2-9	Small	Small	White, yellow or pink flint or pop
2-10	Small	Small	Brown pop or flint
2-11	Small	Small	Yellow flour
2-12	Small	Small	Mixed color flour or flint
3-13	Medium	Medium	Mixed color flour or flint
3-14	Medium	Medium	Yellow flint or pop
3-15	Medium	Medium	White or white and red flour
3-16	Medium	Medium	White flour or flint
3-17	Medium	Medium	Yellow flint or flour
3-18	Medium	Medium	Purpleblack or blue pop, flint or flour
3-19	Medium	Medium	Yellow flour
3-20	Medium	Medium	Purpleblack flour
3-21	Medium	Medium	Blue flour
3-22	Medium	Medium	Red flint
3-23	Medium	Medium	Mixed color flint
4-24	Unspecified, dent	Unspecified	White dent
4-25	Unspecified, dent	Unspecified	Yellow dent
4-26	Unspecified, dent	Unspecified	Mixed color dent
4-27	Unspecified, dent	Unspecified	Orange or yellow dent, flint or flour

[a] Table from Adams et al. (2006, p. 31). Alpha groups are mutually exclusive. Beta groups can occur in more than one alpha group.

Table 20b: Comparison of alpha and beta groupings from Adams et al. (2006) with the clusters from the combined analysis

Accession	Adams alpha group	Adams beta group	Werth cluster [a]
PI 218146	large	1	pueblo
PI 218153	large	1	pueblo
PI 218156	large	1	pueblo
PI 218157	large	1	pueblo
Zuni	large	1	pueblo
PI 218130	large	2	pueblo
PI 218133	large	2	pueblo
PI 218138	large	2	pueblo
PI 218139	large	2	pueblo
PI 218159	large	2	pueblo
PI 218168	large	2	pueblo
PI 218173	large	2	pueblo
PI 218144	large	3	pueblo
PI 218147	large	3	pueblo
PI 218167	large	3	pueblo
PI 218169	large	3	pueblo
PI 218172	large	3	pueblo
PI 218148	large	4	pueblo
PI 218158	large	4	pueblo
PI 218170	large	4	pueblo
NSL 67053	large	5	pueblo
NSL 68325	large	5	pueblo
NSL 68327	large	5	pueblo
PI 218137	large	5	pueblo
NSL 67054	medium	13	pueblo
PI 218145	medium	13	pueblo
PI 218150	medium	13	pueblo
PI 218151	medium	13	pueblo
PI 218141	medium	14	pueblo
PI 218188	medium	14	pueblo
PI 218131	medium	15	pueblo
PI 218143	medium	21	pueblo
NSL 67065	medium	23	pueblo
PI 218171	dent	27	pueblo
PI 218164	large	1	northern
PI 218175	large	1	northern
PI 311229	large	1	northern
PI 420250	large	1	northern
NSL 68332	large	2	northern
PI 213738	large	2	northern

[a] The clusters defined as other are in the small clusters with less than five accessions

Table 20b: continued

Accession	Adams alpha group	Adams beta group	Werth cluster [b]
PI 218176	large	2	northern
PI 317678	large	3	northern
PI 317679	large	3	northern
PI 218135	large	4	northern
PI 218162	large	4	northern
PI 317674	large	4	northern
PI 317675	large	4	northern
NSL 68326	large	5	northern
PI 218165	large	5	northern
PI 218178	large	5	northern
PI 476868	large	5	northern
PI 476870	large	5	northern
NSL 67058	medium	13	northern
PI 213729	medium	13	northern
PI 213737	medium	13	northern
PI 218166	medium	13	northern
PI 476869	medium	13	northern
PI 503564	medium	13	northern
PI 503568	medium	13	northern
PI 218142	medium	14	northern
PI 218149	medium	14	northern
NSL 67064	medium	15	northern
NSL 68334	medium	15	northern
PI 420248	medium	15	northern
PI 503565	medium	15	northern
PI 503567	medium	15	northern
NSL 67066	medium	16	northern
PI 213739	medium	17	northern
PI 218136	medium	19	northern
PI 218160	medium	19	northern
PI 503566	medium	20	northern
NSL 68330	medium	21	northern
NSL 68331	medium	21	northern
PI 503562	medium	21	northern
PI 213733	medium	22	northern
NSL 67060	medium	23	northern
PI 218163	small	6	northern
PI 218134	small	8	northern
PI 485116	medium	14	papago
NSL 68324	medium	16	papago
PI 484433	medium	16	papago
PI 484482	medium	18	papago

Table 20b: continued

Accession	Adams alpha group	Adams beta group	Werth cluster [b]
PI 218185	small	6	papago
PI 218187	small	6	papago
PI 420251	small	6	papago
PI 451716	small	6	papago
NSL 68323	small	7	papago
PI 218186	small	7	papago
PI 503563	small	7	papago
PI 503573	small	7	papago
PI 484413	small	9	papago
PI 213714	small	11	papago
PI 218179	small	12	papago
NSL 67047	dent	24	southern dent
NSL 67048	dent	24	southern dent
NSL 67049	dent	24	southern dent
NSL 67051	dent	24	southern dent
NSL 68336	dent	24	southern dent
PI 218181	dent	24	southern dent
PI 218182	dent	24	southern dent
PI 218183	dent	24	southern dent
PI 218184	dent	24	southern dent
PI 218190	dent	24	southern dent
PI 218191	dent	24	southern dent
NSL 68335	dent	26	southern dent
NSL 68329	medium	13	cornbelt
PI 213728	dent	24	cornbelt
NSL 67052	dent	25	cornbelt
PI 218154	dent	25	cornbelt
NSL 67055	dent	26	cornbelt
Ames 22643	small	8	sweet
PI 218174	small	8	sweet
PI 420247	small	8	sweet
PI 420252	medium	16	other
PI 213741	small	6	other
PI 474206	small	6	other
NSL 2830	small	7	other
PI 213740	small	7	other
PI 490973	small	8	other
PI 218140	small	9	other
PI 474209	small	9	other
PI 420245	small	10	other
PI 629147	dent	24	other

intermediate. The *Pueblo* race has been described as having long ears, big cobs and shanks, many rows, and twice as many tassel branches as the *Pima-Papago* race, with more variability within ethnic groups (Anderson and Cutler, 1942, Carter and Anderson, 1945, Doebley et al., 1983). In this study the landraces with the largest ears are from the Jemez, Isleta, and the Keresan
Pueblos. The morphology of the landraces designated as *Pueblo* (GRIN) is intermediate between the morphology of the *Pueblo* and *Pima-Papago* races.

Racial classification of Southwestern maize landraces is difficult because of the continuum of types, with many intermediates between the extremes. Mixing of landraces through trade and exchange has lead to a continuum of diversity and knowledge of introgression events and their timing is lacking. However, the distinction between Pueblo and Pima-Papago races has been confirmed and clarified, though there should be flexibility in assigning landraces to these races or as intermediates between the two.

CONCLUSION

The importance and diversity of maize in the Southwest, and questions about their relationships to ethnic groups, climate, cultural practices, environmental factors and the interactions of these factors, drove the need to characterize and classify known existing landraces. Maize landraces and human cultures have co-evolved in diverse environments, with maize landraces being shaped by diverse environmental and cultural selection pressures. An understanding of the relationships between landraces can help us understand relationships between cultures, how maize landraces are influenced by environmental factors, and how maize migrated to and within the Southwest. Increased knowledge of the characteristics of these landraces can support increased or better-targeted utilization of these valuable genetic resources.

Analysis of variance identified significant differences among accessions and ethnic groups. Accession by environment interactions were significant for all variables, and environment by ethnic group interactions were significant for several variables. Landraces associated with the Hopi and Mexican ethnic groups and the control group had more variables with a significant accession by environment interaction. Interactions may be due to the landraces in these ethnic groups not being adapted in one or all of the environments.

A graph of the first two principal components showed a continuum of accessions with Keresan Pueblo and Piman landraces at the two extremes, and many intermediates. The only exception to this was a separate cluster with large-eared Hopi and Tohono O'odham landraces and some controls, and a separate group of Chapalote-like Mexican landraces.

Cluster analysis allows a more detailed examination of the relationships between the accessions. Five primary clusters were found, with extreme Pueblo and Piman clusters, an intermediate cluster, a cluster with large-eared Hopi and Tohono O'odham landraces and a cluster with cornbelt accessions. Both analyses (all three environments combined vs. New Mexico environments) have similar major and minor clusters, with 23 accessions clustering differently. The agreement between these two analyses strengthens the conclusions derived from the clustering, even with significant ethnic group by environment interactions taken into account.

The interdependence of maize landraces and human cultures in the Southwest allows useful comparisons relating morphologically relationships between landraces and geographic and cultural factors. Language group relationships are correlated well with the relationships between landraces. There was also a close correspondence with geography and climate. Other factors like agricultural methods, subsistence method and the interactions of Native American groups with the Spanish, do not provide much insight into the relationships found in the clustering. It is difficult to distinguish the impact of specific cultural and environmental factors on the development of maize landraces because of the interdependence of all these factors. However, an understanding of the relationships between landraces can still lead to insights concerning cultural interactions and the effects of climate on the development of diverse landraces.

One cluster included Hopi and Tohono O'odham landraces that are distinct from the other landraces in their respective ethnic groups. These landraces have larger plants and ears and cluster near Mexican June, which was introduced into the Southwest in the early 1900's. One possible cause of the clustering of Southwest landraces with Midwestern controls may be due to introduction and introgression of modern maize into the traditional landraces of the Southwest.

Many previous studies have found a distinction between Pueblo and Piman maize. This distinction is confirmed by this study, with the results of this study being most similar to those of Carter and Anderson (1945). The few differences from Carter and Anderson (1945) may be attributable to differences in the landraces evaluated, or the variables or methodology used. The racial designation done by Carter and Anderson (1945) is also similar to the distinctions found in the cluster analysis, with differences in how maize from Pueblo ethnic groups are classified into the *Pueblo* or *Pima-Papago* race or as intermediates between the two. Carter and Anderson (1945) made racial designations based on averages for an ethnic group and did not distinguish between individual landraces within ethnic groups. In some ethnic groups, individual landraces assign to different clusters, reflecting their diversity; this distinction from Carter and Anderson's work is important. As has been noted, (Anderson and Cutler, 1942) classifying maize is difficult because of the presence of divergent extremes and many intermediates.

Recommendations

The identification of landraces that cluster near Mexican June indicates that modern introductions of maize into the Southwest may have had an impact on Native American maize landraces or had some common lineage. The landraces used in this study were primarily collected in the mid-1900's and do not represent more recent developments in Native American germplasm. An evaluation of currently utilized landraces could provide insight on their current status and relationships to historically sampled landraces. This, coupled with further investigation's on the impact of introduction(s) of commercial maize genetics in Southwestern landraces could help us understand how maize production and/or utilization have changed, and the traits responsible for these changes. This knowledge could be used to support sound decisions by Southwestern producers and consumers, and possible increase utilization of Southwestern landraces.

Many of the landraces evaluated were originally collected in southern Arizona. A field trial in this area is needed, to further investigate the effects of geography and climate on the morphological, agronomic and compositional traits of Southwestern maize landraces. This would improve understanding of the environmental requirements of maize landraces that are adapted to different latitudes and bio-geographic areas within the Southwest.

Further investigation into the genetic makeup of maize landraces can provide more information about the relationships between landraces and their relationships with human cultures. Genetic analysis is particularly important because genetic characterization is not affected by environmental variation, whereas phenotypic expression is affected. Tissue samples were collected during this study and are associated with corresponding phenotypic data on a per plant basis. DNA analyses of these samples could be used to better understand the genetic relationship between landraces and genotype by environmental interaction.

Many archaeological questions need further examination, including questions about the patterns of maize diversity over time, the timing and occurrence of maize migration and/or diffusion into the Southwest, and the relationship between changes in maize landraces and human cultures (Muenchrath et al., 1995). The characterization and classification of Southwestern landraces provides a basis to address these questions. An investigation of the

relationship between archeological and modern landraces is currently being done by Adams et al. (2006).

There is a need for a comprehensive book on indigenous maize landraces, which would describe the relationships between modern and landrace maize varieties and their relationships with international maize varieties (Muenchrath et al., 1995). Comprehensive racial descriptions have been made for the maize of South and Central America in the Races of Maize series, but are lacking in North America. This study fulfills one step in the development of a comprehensive reference for North America maize; there is still need for investigation of maize landraces from other areas of the United States and their inter-relationships.

BIBLIOGRAPHY

Adams, Karen R., Cathryn M. Meegan, Scott G. Ortman, R. Emerson Howell, Lindsay Werth, Deborah A. Muenchrath, Michael K. O'Neill and Candice A. C. Gardner. 2006. MAIS (*Maize of American Indigenous Societies*) Southwest: Ear descriptions and traits that distinguish 27 morphologically distinct groups of 123 historic USDA maize accessions and data relevant to archeological subsistence models. ms. on file with Karen R. Adams.

Anderson, Edgar. 1943. Races of Zea Mays II: A general survey of the problem. Acta Americana 1:58-68.

Anderson. 1945. Maize in the new world. p. 27-42. *In* New Crops for a New World. Charles Morrow. The MacMillian Company, Wilson, NY.

Anderson, Edgar, and Hugh C. Cutler. 1942. Races of Zea Mays: I. Their recognition and classification. Ann. of the Missouri Botanical Garden 29:69-86.

Alvarez, A., and J. M. Lasa. 1987. Asturian populations of maize I. Morphological-vegetative descriptions and variability. An. Aula Dei 18(3-4):177-186.

Bird, Robert McK., and Major M. Goodman. 1977. The races of maize V: Grouping maize races on the basis of ear morphology. Econ. Bot. 31:471-481.

Brieger, F. G., J. T. A. Gurgel, E. Paterniani, A Blumenschein, and M. R. Alleoni. 1958. Races of maize in Brazil and other eastern South American countries. Nat. Acad. of Sci. Natl. Res. Counc. Publ. 593. Washington, D. C.

Brown, William L. 1960. Races of maize in the West Indies. Nat. Acad. of Sci. Natl. Res. Counc. Publ. 792. Washington, D. C.

Brown, William L., and M. M. Goodman. 1977. Races of Corn. p. 49-88. *In* Corn and corn improvement. G. F. Sprague (ed.) ASA, Inc., Madison, WI.

Camussi, A. 1979. Numerical taxonomy of Italian populations of maize based on quantitative traits. Maydica 24:161-174.

Camussi, A., P. L. Spagnoletti Zeuli, and P. Melchiorre. 1983. Numerical taxonomy of Italian maize populations: Genetic distances on the basis of heterotic effects. Maydica 28:411-424.

Carter, George F. 1945. Plant geography and cultural history in the American Southwest. Viking Fund Publ. in Anthropology 5:1-140.

Carter, George F., and Edgar Anderson. 1945. A preliminary survey of maize in the Southwestern United States. Ann. of the Missouri Botanical Garden 32:297-317.

Castetter, Edward F., and Willis H. Bell. 1942. Pima and Papago Indian agriculture. Univ. of New Mexico Press, Albuquerque, NM.

Castetter, Edward F., and Willis H. Bell. 1951. Yuman Indian agriculture. University of New Mexico Press, Albuquerque, NM.

Cleveland, David A., Daniela Soleri, and Steven E. Smith. 1994. Do folk crop varieties have a role in sustainable agriculture? BioScience 44(11):740-751.

Committee on genetic vulnerability of major crops. 1972. Corn. p. 97-118. *In* Genetic vulnerability of major crops. Committee on genetic vulnerability of major crops. Nat. Acad. Sci., Washington, D. C.

Costa-Rodrigues, L. 1971. Races of maize in Portugal. Agronomia lusit 31:239-284.

Day, A. D., D. R. Grove, and R. K. Thompson. 1972. Arizona Indian corn (*Zea mays* L.). J. of the Arizona Acad. of Sci. 7:8-11.

Doebley, J. F., M. M. Goodman, and C. W. Stuber. 1983. Isozyme variation in maize from the southwestern United States: Taxonomic and anthropological implications. Maydica 28:97-120.

Franco, Jorge, Jose Crossa, Jose Villasenor, S. Taba, and Steve A. Eberhart. 1997. Classifying Mexican maize accessions using hierarchical and density search methods. Crop Science 37(3):972-980.

Ford, Richard I. 1994. Corn is our mother. p. 513-525 *In* Corn and culture in the prehistoric New World. Sissel Johannessen and Christine A. Hastorf (ed.) Westview Press, Boulder, Colorado.

Galarreta, J. I. Ruiz de, and A. Alvarez. 2001. Morphological classification of maize landraces from northern Spain. Genetic Resources and Crop Evolution 48:391-400.

Germplasm Resources Information Network (GRIN). 2002. [Online]. www.ars-grin.gov. (accessed October 2004, verified July 2007). ARS-GRIN.

Geric, Ivan, Marija Zlokolica, and Cana Geric. 1989. Races and populations of maize in Yugoslavia. IBPGR, Rome.

Goodman, M. M. 1990. Genetic and germ plasm stocks worth conserving. J. of Heredity 81: 11-16.

Goodman, Major M., Robert McK. Bird. 1977. The races of maize IV: Tentative grouping of 219 Latin American races. Econ. Bot. 31:204-221.

Goodman, Major M., and E. Paterniani. 1969. The races of maize: III. Choices of appropriate characters for racial classification. Econ. Bot. 23:265-273.

Gouesnard B., Dallard J., Panouille A., and Boyat A. 1997. Classification of French maize populations based on morphological traits. Agronomie 17(9/10):491-498.

Grant, U. J., W. H. Hatheway, D. H. Timothy, C. Cassalett D., and L. M. Roberts. 1963. Races of maize in Venezuela. Nat. Acad. of Sci. Natl. Res. Counc. Publ. 1136. Washington, D. C.

Grobman, Alexander, Wilfredo Salhuana, and Ricardo Sevilla. 1961. Races of maize in Perú: Their origins, evolution and classification. Nat. Acad. of Sci. Natl. Res. Counc. Publ. 915. Washington, D. C.

Harlan, J. R. 1975. Our vanishing genetic resources. Science 188:618-621.

Harlan, Jack R. 1992. Crops and man. ASA, CSSA, Madison, WI.

Hatheway, William H. 1957. Races of maize of Cuba. Nat. Acad. of Sci. Natl. Res. Counc. Publ. 453. Washington, D. C.

Hernandez Xolocotzi, Efraim. 1985. Maize and man in the greater Southwest. Economic Botany 39:416-430.

Hernandez X., E. and G. Alanis F. 1970. Estudio morfologico de cinco nuevas razas de maiz de la Sierra Madre Occidental de Mexico: Implicaciones filogeneticas y fitogeograficas. Agrociencia 5:1-194.

Hill, W. W. 1938. The agriculture and hunting methods of the Navaho Indians. Yale University Publ. in Anthropology 18:1-194.

Jorgensen, Joseph G. 1983. Comparative traditional economics and ecological adaptations. p. 684-710. *In* Handbook of North American Indians. Alfonso Ortiz (ed.) Vol. 10. Smithsonian Institution, Washington, D. C.

King, Frances B. 1994. Variability in cob and kernel characteristics of North American maize cultivars. p. 35-54. *In* Corn and culture in the prehistoric new world. Sissel Johannessen and Christine A. Hastork (ed.) Westview Press, Boulder, CO.

Kintigh, Keith W. 1984. Late prehistoric agricultural strategies and settlement patterns in the Zuni area. p. 215-231. *In* Prehistoric agricultural strategies in the Southwest. Suzanne K. Fish and Paul R. Fish (ed.) Arizona State Univ. Anthropological Res. Papers 33. Tempe, AZ.

Kuleshov, N. N. 1933. World's diversity of phenotypes of maize. Journal of the American Society of Agronomy 25:688-700.

Leopold Center for Sustainable Agriculture. 2007. [Online] www.leopold.iastate.edu (accessed July 19, 2007, verified July 20, 2007) The Leopold Center for Sustainable Agriculture Ames, Iowa.

Llaurado, M., and J. Moreno-Gonzalez. 1993. Classification of northern Spanish populations of maize by methods of numerical taxonomy. I. Morphological traits. Maydica 38:15-21.

Longley, A. E. 1938. Chromosomes of maize from North American Indians. J. of Agric. Res. 56(3):177-195.

Malinowski, Sharon and Anna Sheets (ed.) 1998. The Gale Encyclopedia of Native American Tribes. Vol. II. Gale Research, Inc. Detroit, Michigan.

Muenchrath, Deborah A., Peter Bretting, J. Stephen Smith, and Karen R. Adams. 1995. Development of a research proposal for integrating molecular and anthropological approaches to understanding the co-evolution of maize and human cultures. Maize Genetics Cooperation Newsletter. Vol. 69:10-13.

Muenchrath, D. A., Maya Kuratomi, Jonathan A. Sandor, and Jeffrey A. Homburg. 2002. Observation study of maize production systems of Zuni farmers in semiarid New Mexico. J. of Ethnobiology 22(1):1-33.

Mumm, Rita Hogan, and J. W. Dudley. 1994. A classification of 148 US maize inbreds: I. Cluster analysis based on RFLP's. Crop Sci. 34(4):842-851.

Ordas, A., R. A. Maluar, and A. M. de Ron. 1994. Relationships among American and Spanish populations of maize. Euphytica 79:149-161.

Ordas, A., and A. M. de Ron. 1988. A method to measure conicalness in maize. Maydica 33:261-267.

Ortiz, Alfonso (ed.) 1979. Handbook of North American Indians. Vol. 9. Smithsonian Institution, Washington, D. C.

Ortiz, Alfonso (ed.) 1983. Handbook of North American Indians. Vol. 10. Smithsonian Institution, Washington, D. C.

Ortiz R., R. O. 1985. Efecto ambiental, interaccion genotipomedio ambiente y heredabilidad de las caracteristicas morfologicas usadas en la clasificacion racial de maiz en la Sierra del Peru. Unpublished M. S. Thesis. Univ Agraria, La Molina, Peru.

Paterniani E., and M. M. Goodman. 1977. Races of maize in Brazil and adjacent areas. International Maize and Wheat Improvement Center, Mexico.

Revilla, Pedro, and W. F. Tracy. 1995. Morphological characterization and classification of open-pollinated sweet corn cultivars. J. Amer. Soc. Hort. Sci. 120(1):112-118.

Ramirez E., Ricardo, David H. Timothy, Efrain Diaz B., and U. J. Grant. 1960. Races of maize in Bolivia. Nat. Acad. of Sci. Natl. Res. Counc. Publ. 747., Washington, D. C.

Rincon, F., B. Johnson, J. Crossa, and S. Taba. 1996. Cluster analysis, an approach to sampling variability in maize accessions. Maydica 41:307-316.

Robbins, Wilfred William, John Peabody Harrington and Barbara Freire-Marreco. 1916. Ethnobotany of the Tewa Indians. Bureau of American Ethnology, Bull. 55. Washington, D. C.

Roberts, L. M., U. J. Grant, R. Ramirez E., W. H. Hatheway, and D. L. Smith, with P. C. Mangelsdorf. 1957. The races of maize of Colombia. Nat. Acad. of Sci. Natl. Res. Counc. Publ. 510. Washington, D. C.

Salhuana, Wilfredo, and Veronica Machado. 1999. Races of maize in Paraguay. USDA, ARS and The Maize Program of the Paraguayan Ministry of Agriculture and Livestock. Publ. 25. Washington, D. C.

Sanchez G., Jose de Jesus. 1989. Relationships among the Mexican races of maize. Ph.D. diss. North Carolina State Univ, Raleigh, NC.

Sanchez G., J. J., and M. M. Goodman. 1992. Relationships among Mexican and some North American and South American races of maize. Maydica 37:41-51.

Sanchez G., J. J., M. M. Goodman, and J. O. Rawlings. 1993. Appropriate characters for racial classification in maize. Econ. Bot. 47(1):44-59.

Sanchez, P., P. 1983. Estudio de estabilidad de caracteres y razas de maiz de Mexico. Unpublished M. S. Thesis. Colegio de Postgraduados, Chapingo, Mexico.

Singh, Ehag. 1977. Races of maize in India. Indian Council GF Agricultural Research, New Delhi, India.

Sturtevant, E. Lewis. 1880. Indian corn. Charles Van Benthuysen and Sons, Albany, NY.

Timothy, David H., W. H. Hatheway, U. J. Grant, M. Torregroza C., D. SarriaV., and D. Varela A. 1963. Races of maize in Ecuador. Nat. Acad. of Sci. Natl. Res. Counc. Publ. 975. Washington, D. C.

Timothy, David H., Bertulfo Pena V., and Ricardo Ramiriz E. 1961. Races of maize in Chile. Nat. Acad. of Sci. Natl. Res. Counc. Publ. 847. Washington, D. C.

Weatherwax. 1954. Indian corn in old America. The Macmillian Company, New York.

Wellhausen, E. J., Alejandro Fuentes O., and Antonio Hernandez Corzo, with P. C. Mangelsdorf. 1957. Races of maize in Central America. Nat. Acad. of Sci. Natl. Res. Counc. Publ. 511. Washington, D. C.

Wellhausen, E. J., L. M. Roberts, and E. Hernandez X. 1952. Races of maize in México: Their origin, characteristics and distribution. Bussey Institution of Harvard University, Harvard, MA.

Wright, Stephen I., Irie Vroh Bi, Steve G. Schroeder, Masanori Yamasaki, John F. Doebley, Michael D. McMullen and Brandon S. Gaut. 2005. The effects of artificial selection on the maize genome. Science 308:1310-1314.

Zeven, A. C. 1998. Landraces: A review of definitions and classifications. Euphytica 104(2): 127-139.

APPENDIX: Additional tables and figures

Table 21: Provenance information from GRIN

Accession Number	Location collected	Elevation (m)	Collector/ donor [a]	Date collected/ donated	Primary race [b]	Secondary race [b]
Ames 22643	Arizona		Tracy	1983		
Ames 26908	Iowa					
Ames 6048	North Carolina				seam8r	
Ames 19097	Iowa					
NSL 2830	MX		Officina	1959		
NSL 283388	Federal District, MX		CIMMYT	1993	chapal	
NSL 67047	Arizona		SCS	1972		
NSL 67048	Arizona		SCS	1972		
NSL 67049	Arizona		SCS	1972		
NSL 67051	Arizona		SCS	1972		
NSL 67052	Arizona		SCS	1968		
NSL 67053	Arizona		SCS	1968		

[a] Donor abbreviations

Cardenas-F. Cardenas Ramos, Nat. Coordinator of Genetic Resources
CIMMYT-International Maize and Wheat Improvement Center, received through NSSL, Ft. Collins or through Pioneer HiBred International, Inc., Dept of Corn Breeding, Homestead, FL
Cutler-H. Cutler, Missouri Botanical Gardens
Heddon-Heddon, Bureau of Indian Affairs
Nabhan-G. Nabhan, Meals for Millions
Native Seeds/SEARCH-donator M. Drees
Officina de Estudios Especiales
Pioneer-Pioneer Hi-Bred International, Inc.
Powell-E. Powell, Navajo Gospel Mission, received through Nabhan
SCS-USDA Soil Conservation Service
Smith-E. Smith, Oljato Trading Post
SW-Southwestern Indian Crop Conservancy
Tracy-W. Tracy, University of Wisconsin
Wiidakas-W. Wiidakas, North Dakota State University

[b] Race abbreviations

seamdt-Southeastern American Southern Dents
pimpap-Pima-Papago
seam8r-Southeastern American 8-row
nnaff-Northeastern North American Flint and Flour
dulnor-Dulcillo de Noreste
crchih-Cristalino de Chihuahua
cornbd-Cornbelt dent
tuxnor-Tuxpeno Norteno
chapal-Chapalote
revent-Reventador

Table 21: continued

Accession Number	Location collected	Elevation (m)	Collector/ donor [a]	Date collected/ donated	Primary race [b]	Secondary race [b]
NSL 67054	Arizona		SCS	1968		
NSL 67055	Arizona		SCS	1968		
NSL 67056	Arizona		SCS	1968		
NSL 67057	Arizona		SCS	1968		
NSL 67058	Arizona		SCS	1968		
NSL 67059	Arizona		SCS	1968		
NSL 67060	Arizona		SCS	1968		
NSL 67061	Arizona		SCS	1968		
NSL 67062	Arizona		SCS	1968		
NSL 67063	Arizona		SCS	1968		
NSL 67064	Arizona		SCS	1968		
NSL 67065	Arizona		SCS	1968		
NSL 67066	Arizona		SCS	1968		
NSL 67068	Arizona		SCS	1968		
NSL 68323	Arizona		SCS	1969		
NSL 68324	Arizona		SCS	1969		
NSL 68325	Arizona		SCS	1969		
NSL 68326	Arizona		SCS	1969		
NSL 68327	Arizona		SCS	1969		
NSL 68329	Arizona		SCS	1969		
NSL 68330	Arizona		SCS	1969		
NSL 68331	Arizona		SCS	1969		
NSL 68332	Arizona		SCS	1969		
NSL 68334	Arizona		SCS	1969		
NSL 68335	Arizona		SCS	1969		
NSL 68336	Arizona		SCS	1969		
PI 213697	Pennsylvania				cornbd	
PI 213712	Kansas				cornbd	
PI 213714	Arizona		Pioneer	1954		
PI 213728	Arizona		Pioneer	1954		
PI 213729	Arizona		Pioneer	1954		
PI 213730	Arizona		Pioneer	1954		
PI 213732	Oklahoma					
PI 213733	Arizona		Pioneer	1954		
PI 213734	Arizona		Pioneer	1954		
PI 213735	Arizona		Pioneer	1954		
PI 213736	Arizona		Pioneer	1954		

Table 21: continued

Accession Number 3	Location collected	Elevation (m)	Collector/ donor [a]	Date collected/ donated	Primary race [b]	Secondary race [b]
PI 213737	Arizona		Pioneer	1954		
PI 213738	Arizona		Pioneer	1954		
PI 213739	Arizona		Pioneer	1954		
PI 213740	Arizona		Pioneer	1954		
PI 213741	Arizona		Pioneer	1954		
PI 213757	Oklahoma				seam8r	
PI 213767	Unknown Southwest		Pioneer	1954		
PI 217405	Iowa				seamdt	
PI 217408	Iowa				nnaff	
PI 217411	Iowa				nnaff	
PI 218130	New Mexico	1585	Cutler	1953		
PI 218131	New Mexico	1615	Cutler	1953		
PI 218133	New Mexico	1737	Cutler	1953		
PI 218134	New Mexico	2073	Cutler	1953		
PI 218135	New Mexico	2103	Cutler	1953		
PI 218136	New Mexico	2073	Cutler	1953		
PI 218137	New Mexico	2073	Cutler	1953		
PI 218138	New Mexico	1509	Cutler	1953		
PI 218139	New Mexico	1829	Cutler	1953		
PI 218140	New Mexico	2073	Cutler	1953		
PI 218141	New Mexico	1829	Cutler	1953		
PI 218142	New Mexico	2134	Cutler	1953		
PI 218143	New Mexico	1585	Cutler	1953		
PI 218144	New Mexico	1509	Cutler	1953		
PI 218145	New Mexico	1585	Cutler	1953		
PI 218146	New Mexico	1737	Cutler	1953		
PI 218147	New Mexico	1737	Cutler	1953		
PI 218148	New Mexico	1509	Cutler	1953		
PI 218149	New Mexico	2134	Cutler	1953		
PI 218150	New Mexico	1615	Cutler	1953		
PI 218151	New Mexico	1615	Cutler	1953		
PI 218152	New Mexico	2134	Cutler	1953		
PI 218153	New Mexico	1585	Cutler	1953		
PI 218154	New Mexico	1585	Cutler	1953		
PI 218155	New Mexico	1585	Cutler	1953		
PI 218156	New Mexico	1585	Cutler	1953		

Table 21: continued

Accession Number	Location collected	Elevation (m)	Collector/ donor [a]	Date collected/ donated	Primary race [b]	Secondary race [b]
PI 218157	New Mexico	1585	Cutler	1953		
PI 218158	New Mexico	1829	Cutler	1953		
PI 218159	New Mexico	1829	Cutler	1953		
PI 218160	Arizona	1615	Cutler	1953		
PI 218161	Arizona	1615	Cutler	1953		
PI 218162	Arizona	1615	Cutler	1953		
PI 218163	Arizona	1615	Cutler	1953		
PI 218164	Arizona	1615	Cutler	1953		
PI 218165	Arizona	1615	Cutler	1953		
PI 218166	Arizona	1615	Cutler	1953		
PI 218167	New Mexico	1829	Cutler	1953		
PI 218168	New Mexico	1829	Cutler	1953		
PI 218169	New Mexico	1768	Cutler	1953		
PI 218170	New Mexico	1768	Cutler	1953		
PI 218171	New Mexico	2073	Cutler	1953		
PI 218172	New Mexico	1829	Cutler	1953		
PI 218173	New Mexico	1829	Cutler	1953		
PI 218174	Arizona	1311	Cutler	1954		
PI 218175	Arizona	1311	Cutler	1953		
PI 218176	Arizona	1311	Cutler	1953		
PI 218178	Arizona	1311	Cutler	1953		
PI 218179	Arizona	701	Cutler	1953		
PI 218180	Arizona	701	Cutler	1953	seamdt	
PI 218181	Arizona	701	Cutler	1953	seamdt	
PI 218182	Arizona	701	Cutler	1953	seamdt	
PI 218183	Arizona	701	Cutler	1953	seamdt	
PI 218184	Arizona	701	Cutler	1953	seamdt	
PI 218185	Arizona	701	Cutler	1953		
PI 218186	Arizona	91	Cutler	1954		
PI 218187	Arizona	91	Cutler	1954		
PI 218188	New Mexico	1829	Cutler	1953		
PI 218189	Arizona	30	Cutler	1954	seamdt	
PI 218190	Arizona	701	Cutler	1953		
PI 218191	Arizona	701	Cutler	1953	seamdt	
PI 222285	Arizona		Wiidakas	1914	nnaff	
PI 311229	Arizona		Smith	1963		
PI 311243	Virginia				seamdt	

Table 21: continued

Accession Number	Location collected	Elevation (m)	Collector/ donor [a]	Date collected/ donated	Primary race [b]	Secondary race [b]
PI 317674	Arizona		Heddon	1965		
PI 317675	Arizona		Heddon	1965		
PI 317678	Arizona		Heddon	1965		
PI 317679	Arizona		Heddon	1965		
PI 408705	Iowa				cornbd	
PI 420245	Sinaloa, MX		Nabhan	1977	chapal	
PI 420247	Arizona		Nabhan	1977		
PI 420248	Arizona		Nabhan	1977		
PI 420250	Arizona		Nabhan	1977		
PI 420251	Arizona		Nabhan	1977	pimpap	
PI 420252	Sonora, MX		Nabhan	1977		
PI 451716	Arizona		SW	1979	pimpap	
PI 474206	Sonora, MX	500	Powell	1982		
PI 474209	Sonora, MX	500	Powell	1982		
PI 476868	New Mexico	2000	Nabhan	1983		
PI 476869	Arizona	1700	Nabhan	1983		
PI 476870	Arizona	1700	Native Seeds	1983		
PI 484413	Chihuahua, MX		CIMMYT	1983	apachi	crchih
PI 484433	Chihuahua, MX		CIMMYT	1983	gordo	crchih
PI 484482	Chihuahua, MX		CIMMYT	1983	crchih	azul
PI 485116	Chihuahua, MX		CIMMYT	1983	crchih	
PI 490921	Jalisco, MX		CIMMYT 2	1984	revent	
PI 490973	Sonora, MX		CIMMYT	1984	dulnor	
PI 503562	Arizona		Native Seeds	1984	pueblo	
PI 503563	Arizona		Native Seeds	1985	pimpap	
PI 503564	Arizona		Native Seeds	1985	pueblo	
PI 503565	Arizona		Native Seeds	1985	pueblo	
PI 503566	Arizona		Native Seeds	1984	pueblo	
PI 503567	Arizona		Native Seeds	1985	pueblo	
PI 503568	Arizona		Native Seeds	1968	pueblo	
PI 503573	Arizona		Native Seeds	1985	pimpap	
PI 508270	Arizona					
PI 550563	Arizona					
PI 629147	Coahuila, MX	1400	Cardenas	1952	tuxnor	
Zuni	New Mexico					

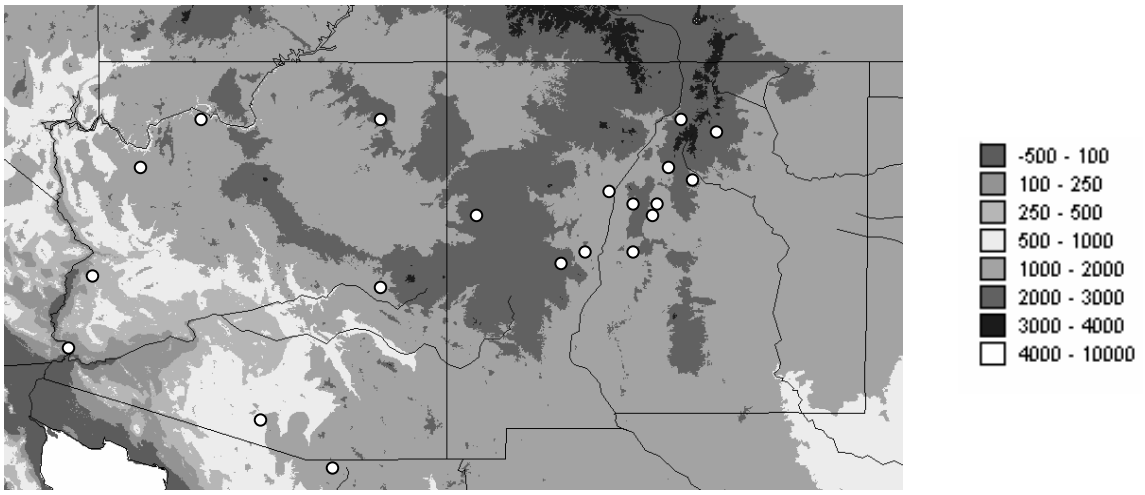

Figure 13: Elevation (m) in Arizona and New Mexico

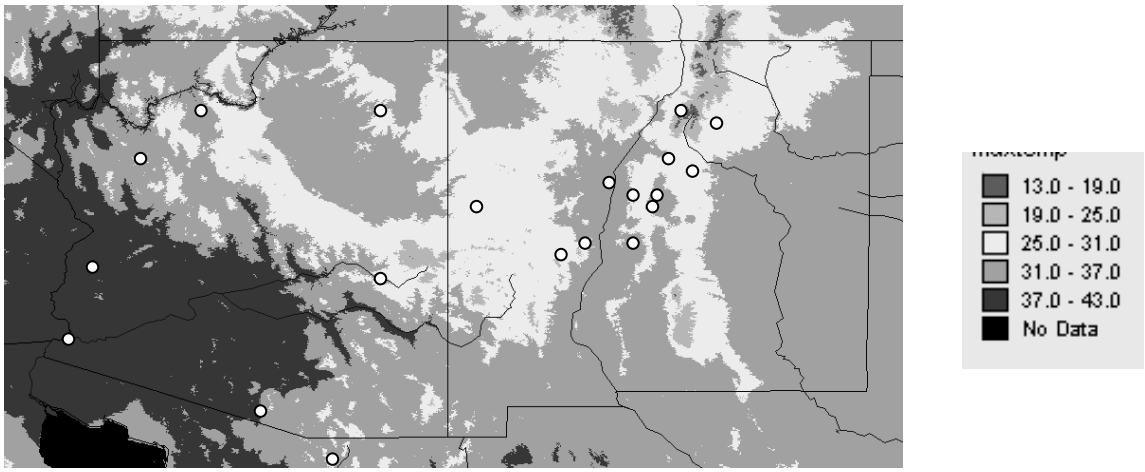

Figure 14: Average July temperature (degrees C) in Arizona and New Mexico

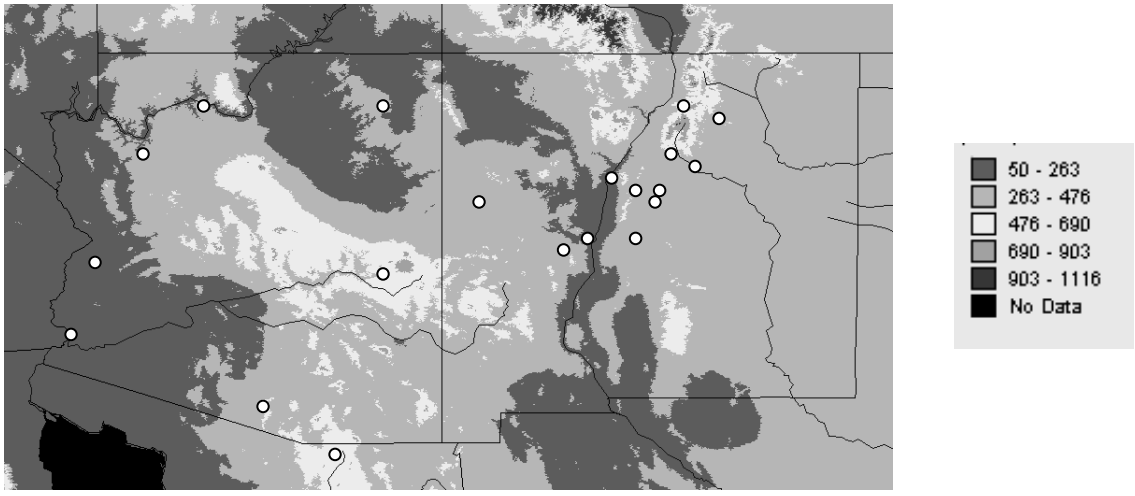

Figure 15: Average annual precipitation (mm) in Arizona and New Mexico

Table 22: Landrace means by ethnic group in New Mexico 2004, New Mexico 2005 and Iowa 2004, for variables with a significant interaction between ethnic group and environment

Ethnic group	gdd5s mean			earheight mean			leaves mean		
	IA 04	NM 04	NM 05	IA 04	NM 04	NM 05	IA 04	NM 04	NM 05
Acoma Pueblo	1409	1587	1596	85.41	78.99	79.35	11.49	16.78	16.71
Control	1374	1719	1665	113.63	85.48	80.90	13.89	18.18	17.86
Santa Clara Pueblo	1360	1583	1584	101.19	77.38	85.63	12.72	17.83	17.81
Cochiti Pueblo	1418	1657	1633	96.60	78.02	80.11	12.61	17.04	17.59
Santo Domingo Pueblo	1438	1735	1714	111.01	99.17	99.92	13.56	18.55	18.41
San Felipe Pueblo	1414	1692	1679	113.65	94.06	103.69	13.80	17.90	18.86
Havasupai	1381	1622	1650	51.508	49.55	53.09	11.14	16.36	16.88
Hopi	1324	1541	1541	73.608	61.13	64.10	11.32	15.95	16.26
Isleta Pueblo	1514	1761	1765	115.71	93.71	105.90	14.00	18.15	18.51
Jemez Pueblo	1507	1716	1741	127.15	100.81	107.01	13.86	18.65	18.89
Laguna Pueblo	1474	1669	1661	94.20	83.32	92.06	12.30	17.00	17.66
Large	1635	1978	1860	184.85	143.61	151.14	17.92	21.33	20.60
Mexico	1621	1820	1582	150.35	101.37	114.47	14.31	17.49	17.62
Mojave	1252	1428	1412	66.30	48.46	48.97	10.98	15.70	15.48
Navajo	1268	1496	1453	48.80	46.73	48.55	9.92	15.01	15.06
Other	1281	1490	1471	69.40	48.45	50.95	10.89	15.60	15.30
Picuris	1187	1311	1316	50.91	43.03	40.37	9.86	15.57	14.56
Pima-Maricopa	1262	1338	1395	71.10	46.47	55.26	10.75	14.95	15.37
San Carlos Apache	1317	1604	1678	67.01	39.94	62.47	9.89	14.56	16.03
Taos Pueblo	1179	1356	1357	55.11	51.05	51.42	10.24	15.81	15.16
Tesuque Pueblo	1305	1509	1507	68.01	53.61	61.61	11.14	16.26	16.23
Tohono O'odham	1323	1484	1457	85.10	60.22	67.34	11.42	15.55	15.99
Walapai	1185	1498	1415	62.60	58.09	47.09	11.06	15.34	14.92
White Mountain Apache	1394	1625	1652	71.01	61.15	58.98	11.65	15.85	15.95
Zia Pueblo	1519	1741	1741	116.64	94.85	106.54	13.33	17.72	18.43
Zuni	1318	1515	1506	80.20	80.79	70.15	11.78	16.82	16.72

Table 22: continued

Ethnic group	nodes mean			circ mean			plantear mean		
	IA 04	NM 04	NM 05	IA 04	NM 04	NM 05	IA 04	NM 04	NM 05
Acoma Pueblo	5.78	10.58	10.94	80.87	86.42	90.24	2.76	2.35	2.16
Control	7.54	12.35	11.70	72.86	75.48	78.04	2.17	2.11	2.25
Santa Clara Pueblo	6.54	11.84	11.64	69.72	83.50	93.33	2.43	2.39	2.18
Cochiti Pueblo	6.43	11.04	11.28	78.88	80.49	87.99	2.40	2.30	2.22
Santo Domingo Pueblo	6.87	12.38	11.90	75.82	86.76	90.61	2.21	2.02	2.11
San Felipe Pueblo	7.69	11.91	12.48	71.14	81.94	88.31	2.18	2.07	2.06
Havasupai	5.21	10.00	10.66	78.42	86.29	91.56	3.21	2.53	2.62
Hopi	5.76	10.15	10.47	71.06	75.89	82.29	2.79	2.49	2.49
Isleta Pueblo	7.41	11.67	12.10	81.14	93.15	96.20	2.39	2.13	2.68
Jemez Pueblo	7.65	12.24	12.32	78.13	86.94	92.36	2.13	2.12	2.06
Laguna Pueblo	6.39	11.04	11.36	78.78	87.31	93.11	2.04	2.13	1.94
Large	11.62	15.62	14.46	89.30	87.88	87.79	2.46	2.23	2.07
Mexico	9.15	12.42	12.23	72.53	70.49	71.95	1.65	1.58	1.61
Mojave	5.35	10.72	9.97	63.33	65.93	68.19	1.83	1.89	1.88
Navajo	4.61	9.66	9.40	69.49	74.98	80.24	2.82	2.78	2.80
Other	5.57	10.13	9.59	65.62	71.59	77.76	3.80	2.83	2.88
Picuris Pueblo	4.17	9.81	8.62	72.42	80.42	86.28	3.36	2.90	2.82
Pima-Maricopa	5.83	9.96	9.86	63.75	62.76	68.42	3.66	3.06	3.48
San Carlos Apache	5.28	9.61	10.57	58.50	69.17	69.38	3.06	2.98	3.05
Taos Pueblo	4.41	9.83	9.07	75.21	75.54	82.61	2.93	2.95	2.54
Tesuque Pueblo	5.37	10.50	10.32	67.08	73.91	79.79	3.26	2.95	2.93
Tohono O'odham	6.57	10.67	10.66	59.72	59.91	68.97	2.91	2.70	2.44
Walapai	6.33	9.88	9.89	60.39	61.22	67.44	2.60	2.31	2.37
White Mountain Apache	5.71	10.15	10.11	65.34	70.59	75.57	2.84	2.51	2.65
Zia Pueblo	7.19	11.53	12.12	79.00	88.13	91.49	2.23	2.21	1.99
Zuni	5.44	10.21	10.56	73.33	84.39	89.17	2.86	2.52	2.58

Table 22: continued

Ethnic group	GDDleafnum5 mean			branch mean			branching mean		
	IA 04	NM 04	NM 05	IA 04	NM 04	NM 05	IA 04	NM 04	NM 05
Acoma Pueblo	124.48	95.09	96.33	20.75	20.50	15.76	16.37	16.15	19.49
Control	102.23	95.58	95.27	17.49	17.99	13.90	15.80	13.47	17.09
Santa Clara Pueblo	107.74	89.03	90.64	20.65	21.61	16.32	16.62	15.03	18.71
Cochiti Pueblo	115.10	97.80	93.45	20.38	20.90	15.35	15.74	13.74	18.32
Santo Domingo Pueblo	107.83	94.37	93.94	18.62	20.15	15.74	15.76	14.76	19.07
San Felipe Pueblo	104.28	95.42	89.79	22.12	20.22	15.69	17.93	15.14	19.73
Havasupai	126.34	100.36	98.33	14.80	16.78	13.11	11.35	11.30	13.65
Hopi	121.14	98.01	95.99	15.00	16.67	13.35	13.30	12.41	15.24
Isleta Pueblo	110.13	97.77	96.09	20.72	19.98	14.91	15.04	13.83	16.94
Jemez Pueblo	109.36	92.53	92.64	20.21	19.10	15.89	17.97	15.69	17.57
Laguna Pueblo	121.64	98.64	94.46	17.90	21.10	16.71	14.57	14.66	18.04
Large	92.43	93.08	88.87	21.06	19.81	17.70	19.16	16.41	18.07
Mexico	117.82	105.19	97.76	17.95	14.81	12.99	15.86	12.36	14.96
Mojave	116.08	91.76	91.81	12.06	11.14	10.37	9.52	8.17	8.64
Navajo	130.95	100.39	97.66	14.55	16.92	14.37	13.08	12.68	15.31
Other	122.42	96.42	96.79	15.70	17.10	13.44	11.98	11.16	13.75
Picuris Pueblo	121.73	85.78	91.86	14.30	20.39	13.23	13.03	14.10	14.36
Pima-Maricopa	120.37	90.27	92.01	13.61	14.61	9.83	11.36	8.91	12.55
San Carlos Apache	136.64	111.04	105.29	8.48	9.56	9.46	10.56	8.28	15.71
Taos Pueblo	121.97	86.51	91.62	15.65	18.59	16.72	13.36	13.38	15.07
Tesuque Pueblo	121.59	94.31	94.10	16.45	16.65	14.77	13.91	13.63	16.37
Tohono O'odham	118.76	96.36	91.89	13.35	14.26	11.48	11.63	9.44	13.00
Walapai	109.51	99.00	96.18	5.82	7.61	6.20	5.60	7.11	7.24
White Mountain Apache	121.63	103.90	104.41	13.77	17.61	13.86	14.13	13.36	15.63
Zia Pueblo	115.54	99.00	95.10	21.57	19.71	17.31	17.69	15.60	19.53
Zuni	113.57	91.06	90.43	21.33	23.67	15.47	16.83	15.83	16.44

Table 22: continued

Ethnic group	tassel mean			elength mean			eweight mean		
	IA 04	NM 04	NM 05	IA 04	NM 04	NM 05	IA 04	NM 04	NM 05
Acoma Pueblo	49.78	51.81	56.05	22.86	24.52	23.60	189.82	228.36	214.56
Control	48.99	43.16	49.81	19.61	18.69	19.64	176.44	160.59	194.23
Santa Clara Pueblo	48.96	48.53	53.84	20.52	23.43	25.72	146.11	201.25	218.86
Cochiti Pueblo	45.34	45.68	53.28	21.82	23.99	24.79	151.25	201.84	209.62
Santo Domingo Pueblo	49.17	48.67	53.33	22.42	23.97	25.74	166.68	211.85	231.69
San Felipe Pueblo	50.16	48.61	52.27	23.75	25.88	25.78	200.47	231.28	237.84
Havasupai	38.24	40.07	44.16	18.66	21.55	23.51	112.68	154.58	171.33
Hopi	43.13	44.15	48.71	19.40	21.20	21.72	133.90	164.59	173.52
Isleta Pueblo	44.15	46.78	50.54	22.35	24.36	25.05	176.71	272.88	280.91
Jemez Pueblo	51.42	50.01	52.34	24.37	25.48	26.42	220.80	276.59	298.26
Laguna Pueblo	46.34	48.91	52.67	23.11	24.16	25.20	165.50	219.79	239.19
Large	51.31	45.79	48.68	19.84	18.63	19.11	222.78	181.93	218.85
Mexico	51.26	45.11	48.58	19.10	18.58	20.43	105.41	108.94	132.81
Mojave	39.19	38.83	40.05	19.80	20.09	19.63	91.42	109.74	102.96
Navajo	41.17	43.45	47.62	18.59	20.78	20.89	107.62	143.11	143.21
Other	43.75	39.95	44.81	15.85	17.89	17.17	87.48	120.19	107.53
Picuris Pueblo	44.64	44.06	47.95	19.30	22.29	20.38	133.98	163.20	154.36
Pima-Maricopa	45.76	40.64	48.20	17.34	18.56	19.27	96.17	104.45	115.26
San Carlos Apache	44.54	39.56	51.53	14.56	15.18	15.93	49.80	46.33	61.95
Taos Pueblo	43.92	44.94	48.36	20.36	22.66	24.69	152.99	182.16	191.68
Tesuque Pueblo	42.80	47.02	51.34	18.37	20.22	20.53	117.03	153.47	150.59
Tohono O'odham	43.94	39.62	47.38	19.01	18.51	20.04	105.31	97.89	118.07
Walapai	31.04	35.31	38.71	16.01	16.04	17.72	42.06	65.62	83.12
White Mountain Apache	43.26	44.34	45.59	17.04	18.42	19.92	112.61	130.83	154.26
Zia Pueblo	47.55	49.47	53.93	26.21	27.51	27.05	194.18	230.17	250.72
Zuni	51.07	48.44	51.39	23.58	26.07	25.83	172.64	225.36	232.01

Table 22: continued

Ethnic group	weightear mean			kv mean		
	IA 04	NM 04	NM 05	IA 04	NM 04	NM 05
Acoma Pueblo	148.44	175.80	173.46	26.67	27.22	25.67
Control	156.65	140.88	166.01	26.70	23.56	25.58
Santa Clara Pueblo	129.77	164.08	184.25	21.67	22.67	20.33
Cochiti Pueblo	119.92	161.49	173.68	20.83	22.43	22.00
Santo Domingo Pueblo	123.36	164.67	186.77	21.33	22.75	22.08
San Felipe Pueblo	159.24	182.09	198.22	23.83	22.17	21.17
Havasupai	87.39	125.04	150.48	23.11	27.01	25.27
Hopi	116.36	131.91	144.57	23.31	24.39	23.94
Isleta Pueblo	166.95	208.61	214.59	23.80	25.71	25.11
Jemez Pueblo	160.52	213.50	234.40	29.33	28.56	28.78
Laguna Pueblo	136.02	169.67	192.19	23.15	24.77	25.07
Large	175.15	137.81	174.25	27.33	22.36	22.60
Mexico	102.51	97.16	115.36	21.05	19.22	19.45
Mojave	83.61	88.93	86.56	24.17	23.00	22.83
Navajo	92.11	118.88	126.39	21.59	22.00	22.76
Other	76.10	94.77	92.35	18.60	19.25	17.58
Picuris Pueblo	103.92	115.99	112.30	23.50	25.67	25.50
Pima-Maricopa	87.65	87.39	94.65	20.00	18.83	19.00
San Carlos Apache	44.84	45.55	51.15	22.00	17.33	21.00
Taos Pueblo	118.44	144.64	150.18	24.81	25.00	25.89
Tesuque Pueblo	96.42	120.70	119.27	19.33	20.44	20.56
Tohono O'odham	84.68	82.07	100.49	20.73	17.93	20.73
Walapai		43.76	80.80	22.00	23.00	21.67
White Mountain Apache	100.58	101.28	121.80	23.00	21.12	21.78
Zia Pueblo	146.23	173.47	197.91	23.64	23.83	23.83
Zuni	124.83	182.95	190.65	22.67	24.00	23.00

Table 22: continued

Ethnic group	k10 mean			rachisseg mean		
	IA 04	NM 04	NM 05	IA 04	NM 04	NM 05
Acoma Pueblo	30.32	30.79	30.71	4.91	4.26	4.41
Control	32.10	27.59	31.09	4.23	3.59	4.10
Santa Clara Pueblo	25.97	25.94	23.28	4.72	4.27	4.30
Cochiti Pueblo	22.85	25.35	25.91	4.54	3.58	4.39
Santo Domingo Pueblo	23.52	26.03	26.28	4.77	3.81	4.46
San Felipe Pueblo	27.23	26.59	26.02	4.46	3.81	3.85
Havasupai	25.44	29.70	28.37	5.27	4.13	4.97
Hopi	27.11	27.83	28.56	4.78	3.91	4.56
Isleta Pueblo	26.82	29.14	28.72	4.80	3.94	4.70
Jemez Pueblo	31.58	32.58	34.36	4.99	4.01	4.65
Laguna Pueblo	25.72	26.92	28.51	4.72	3.85	4.70
Large	31.88	25.44	27.96	4.07	3.57	3.74
Mexico	28.64	24.66	25.07	4.85	3.68	4.24
Mojave	24.90	26.97	26.66	5.07	4.11	4.86
Navajo	23.57	24.93	27.34	4.85	3.91	4.74
Other	23.10	22.78	22.02	4.58	3.67	4.04
Picuris Pueblo	26.50	28.31	29.65	4.70	4.12	4.72
Pima-Maricopa	23.07	22.07	23.22	4.73	3.77	4.17
San Carlos Apache	25.92	23.03	24.21	5.14	3.77	4.35
Taos Pueblo	30.05	29.03	31.68	4.99	4.00	5.02
Tesuque Pueblo	22.57	23.68	24.75	4.65	4.03	4.61
Tohono O'odham	23.08	20.12	24.37	5.00	3.69	4.43
Walapai		23.49	26.98	5.17	4.18	4.51
White Mountain Apache	26.88	24.79	25.54	4.31	3.63	4.09
Zia Pueblo	26.09	26.85	28.19	4.82	4.16	4.77
Zuni	24.60	27.22	27.66	4.89	3.71	4.89

Table 23: Accession order on the dendogram for the combined cluster analysis

Accession number	Ethnic group	Racial assignment	Cluster ID (combined)
Zuni	Zuni		pueblo
NSL 67054	Hopi		pueblo
NSL 67065	Hopi		pueblo
PI 218188	Zia		pueblo
PI 218143	Santo Domingo Pueblo		pueblo
PI 218156	Santo Domingo Pueblo		pueblo
PI 218157	Santa Clara Pueblo		pueblo
PI 218150	Cochiti Pueblo		pueblo
NSL 67053	Hopi		pueblo
NSL 68325	Hopi		pueblo
PI 218131	Cochiti Pueblo		pueblo
PI 218141	Acoma Pueblo		pueblo
NSL 68327	Hopi		pueblo
PI 218137	Tesuque Pueblo		pueblo
PI 218146	Laguna Pueblo		pueblo
PI 218168	Acoma Pueblo		pueblo
PI 218151	Cochiti Pueblo		pueblo
PI 218170	Laguna Pueblo		pueblo
PI 218145	Cochiti Pueblo		pueblo
PI 218153	San Felipe Pueblo		pueblo
PI 218130	Santo Domingo Pueblo		pueblo
PI 218144	Isleta Pueblo		pueblo
PI 218147	Laguna Pueblo		pueblo
PI 218148	Isleta Pueblo		pueblo
PI 218133	Laguna Pueblo		pueblo
PI 218138	Isleta Pueblo		pueblo
PI 218171	Jemez Pueblo		pueblo
PI 218172	Jemez Pueblo		pueblo
PI 218139	Zia Pueblo		pueblo
PI 218158	Zia Pueblo		pueblo
PI 218159	Zia Pueblo		pueblo
PI 218155	Santo Domingo Pueblo		pueblo
PI 218169	Laguna Pueblo		pueblo
PI 218173	Jemez Pueblo		pueblo
PI 218167	Acoma Pueblo		pueblo
Ames 19097	Control		cornbelt
Ames 26908	Control		cornbelt
PI 218154	San Felipe Pueblo		cornbelt
NSL 67052	Hopi		cornbelt

Table 23: continued

Accession number	Ethnic group	Racial assignment	Cluster ID (combined)
PI 213712	Control	cornbd	cornbelt
PI 311243	Mexico	seamdt	cornbelt
NSL 67055	Hopi		cornbelt
PI 213697	Control	cornbd	cornbelt
NSL 67062	Hopi		cornbelt
NSL 67063	Hopi		cornbelt
NSL 68329	Hopi		cornbelt
PI 213728	White Mountain Apache		cornbelt
PI 408705	Control	cornbd	cornbelt
NSL 67047	Hopi		southern dent
PI 218191	Tohono O'odham	seamdt	southern dent
PI 218184	Tohono O'odham	seamdt	southern dent
NSL 67048	Hopi	seamdt	southern dent
PI 218182	Tohono O'odham	seamdt	southern dent
NSL 67051	Hopi		southern dent
PI 218190	Tohono O'odham		southern dent
NSL 67068	Hopi		southern dent
NSL 68336	Hopi		southern dent
NSL 68335	Hopi		southern dent
PI 218181	Tohono O'odham	seamdt	southern dent
PI 218180	Tohono O'odham	seamdt	southern dent
PI 218183	Tohono O'odham	seamdt	southern dent
PI 508270	Control (Arizona germplasm)		southern dent
PI 550563	Control (Arizona germplasm)		southern dent
NSL 67049	Hopi	seamdt	southern dent
PI 217405	Control	seamdt	southern dent
PI 218189	Tohono O'odham	seamdt	southern dent
PI 420252	Mexico		1
PI 629147	Mexico	tuxnor	1
NSL 2830	Mexico		2
PI 213757	Control (Quapaw)	seam8r	2
Ames 6048	Control (Cherokee)	seam8r	3
PI 213732	Control (Arapaho)		3
PI 217408	Control	nnaff	4
Ames 22643	Hopi		5
PI 420247	Hopi (Shungopovi)		5
PI 218174	Hopi (Moencopi)		5
PI 213730	White Mountain Apache		5
NSL 67056	Hopi		northern
NSL 67061	Hopi		northern

Table 23: continued

Accession number	Ethnic group	Racial assignment	Cluster ID (combined)
NSL 67060	Hopi		northern
NSL 67058	Hopi		northern
NSL 67059	Hopi		northern
PI 213739	Navajo		northern
PI 218134	Tesuque Pueblo		northern
NSL 67057	Hopi		northern
NSL 67066	Hopi		northern
NSL 67064	Hopi		northern
PI 218176	Hopi (Moencopi)		northern
PI 218178	Hopi (Moencopi)		northern
PI 476870	Havasupai-Hopi		northern
NSL 68326	Hopi		northern
NSL 68330	Hopi		northern
PI 218163	Navajo		northern
PI 218162	Navajo		northern
PI 218164	Navajo		northern
PI 476869	Hopi (New Oraibi)		northern
PI 218165	Navajo		northern
PI 218166	Navajo		northern
PI 503562	Hopi (Kiakochomovi)	pueblo	northern
PI 503566	Hopi (Hotevilla)	pueblo	northern
PI 218175	Hopi (Moencopi)		northern
PI 503565	Hopi (Hotevilla)	pueblo	northern
PI 503568	Navajo	pueblo	northern
NSL 68331	Hopi		northern
PI 317678	Havasupai		northern
PI 213735	Hopi (Hotevilla)		northern
PI 317675	Havasupai		northern
PI 420248	Hopi (Shungopovi)		northern
PI 218161	Navajo		northern
PI 218160	Navajo		northern
PI 503564	Hopi (Bakabi)	pueblo	northern
PI 311229	Navajo		northern
PI 213729	White Mountain Apache		northern
PI 317674	Havasupai		northern
PI 317679	Havasupai		northern
NSL 68332	Hopi		northern
PI 213734	Hopi (Hotevilla)		northern
PI 420250	Hopi (Shungopovi)		northern
NSL 68334	Hopi		northern

Table 23: continued

Accession number	Ethnic group	Racial assignment	Cluster ID (combined)
PI 503567	Hopi (Hotevilla)	pueblo	northern
PI 213733	Hopi (Hotevilla)		northern
PI 218136	Tesuque Pueblo		northern
PI 213737	Navajo		northern
PI 213738	Navajo		northern
PI 476868	Taos		northern
PI 218135	Picuris Pueblo		northern
PI 218142	Picuris Pueblo		northern
PI 218149	Taos Pueblo		northern
PI 218152	Taos Pueblo		northern
PI 213767	Unknown Pueblo		northern
NSL 68323	Hopi		papago
PI 218186	Mojave		papago
PI 503573	Tohono O'odham	pimpap	papago
PI 420251	Pima-Maricopa	pimpap	papago
PI 484413	Mexico	apachi (crchih)	papago
PI 451716	Tohono O'odham	pimpap	papago
NSL 68324	Hopi		papago
PI 485116	Mexico	crchih	papago
PI 218187	Mojave		papago
PI 213714	Tohono O'odham	pimpap	papago
PI 218179	Tohono O'odham		papago
PI 503563	Pima-Maricopa	pimpap	papago
PI 218185	Tohono O'odham		papago
PI 484433	Mexico	gordo (crchih)	papago
PI 484482	Mexico	crchih (azul)	papago
PI 213736	San Carlos Apache		papago
PI 217411	Control (Mesquakie)	nnaff	papago
PI 213741	Walapai		6
PI 222285	Navajo	nnaff	6
PI 213740	Navajo		7
PI 218140	Acoma Pueblo		8
NSL 283388	Mexico	chapal	9
PI 420245	Mexico	chapal	9
PI 490921	Mexico	revent	9
PI 474206	Mexico		10
PI 490973	Mexico	dulnor	10
PI 474209	Mexico		10

Table 24: Accession order for the dendogram for the New Mexico cluster analysis

Accession	Ethnic group	Racial assignment	Cluster ID (New Mexico)
Zuni	Zuni		pueblo
PI 218157	Santa Clara Pueblo		pueblo
PI 218143	Santo Domingo Pueblo		pueblo
PI 218156	Santo Domingo Pueblo		pueblo
PI 218150	Cochiti Pueblo		pueblo
PI 218151	Cochiti Pueblo		pueblo
NSL 67065	Hopi		pueblo
PI 218168	Acoma Pueblo		pueblo
PI 218188	Zia Pueblo		pueblo
PI 218153	San Felipe Pueblo		pueblo
NSL 67053	Hopi		pueblo
NSL 67054	Hopi		pueblo
PI 218155	Santo Domingo Pueblo		pueblo
NSL 68325	Hopi		pueblo
NSL 67056	Hopi		pueblo
PI 218141	Acoma Pueblo		pueblo
PI 218146	Laguna Pueblo		pueblo
PI 218131	Cochiti Pueblo		pueblo
NSL 67060	Hopi		pueblo
NSL 67061	Hopi		pueblo
NSL 68326	Hopi		pueblo
NSL 68327	Hopi		pueblo
PI 503568	Navajo	pueblo	pueblo
PI 218170	Laguna Pueblo		pueblo
PI 218175	Hopi (Moencopi)		pueblo
PI 503565	Hopi (Hotevilla)	pueblo	pueblo
PI 317674	Havasupai		pueblo
PI 317679	Havasupai		pueblo
PI 218137	Tesuque Pueblo		pueblo
PI 218130	Santo Domingo Pueblo		pueblo
PI 218144	Isleta Pueblo		pueblo
PI 218147	Laguna Pueblo		pueblo
PI 218148	Isleta Pueblo		pueblo
PI 218133	Laguna Pueblo		pueblo
PI 218139	Zia Pueblo		pueblo
PI 218169	Laguna Pueblo		pueblo
PI 218173	Jemez Pueblo		pueblo
PI 218158	Zia Pueblo		pueblo
PI 218159	Zia Pueblo		pueblo

Table 24: continued

Accession	Ethnic group	Racial assignment	Cluster ID (New Mexico)
PI 218138	Isleta Pueblo		pueblo
PI 218167	Acoma Pueblo		pueblo
PI 218171	Jemez Pueblo		pueblo
PI 218172	Jemez Pueblo		pueblo
NSL 67057	Hopi		northern
NSL 67064	Hopi		northern
NSL 67066	Hopi		northern
PI 218176	Hopi (Moencopi)		northern
PI 476870	Havasupai-Hopi		northern
PI 218178	Hopi (Moencopi)		northern
NSL 68334	Hopi		northern
PI 503567	Hopi (Hotevilla)	pueblo	northern
NSL 68330	Hopi		northern
PI 218163	Navajo		northern
PI 218162	Navajo		northern
PI 218164	Navajo		northern
PI 218165	Navajo		northern
PI 218166	Navajo		northern
NSL 68331	Hopi		northern
PI 503564	Hopi (Bakabi)	pueblo	northern
PI 503562	Hopi (Kiakochomovi)	pueblo	northern
PI 503566	Hopi (Hotevilla)	pueblo	northern
PI 311229	Navajo		northern
PI 317675	Havasupai		northern
PI 317678	Havasupai		northern
NSL 68332	Hopi		northern
PI 213734	Hopi (Hotevilla)		northern
PI 420250	Hopi (Shungopovi)		northern
PI 213733	Hopi (Hotevilla)		northern
PI 218136	Tesuque Pueblo		northern
PI 476869	Hopi (New Oraibi)		northern
PI 213735	Hopi (Hotevilla)		northern
PI 420248	Hopi (Shungopovi)		northern
PI 213738	Navajo		northern
PI 218160	Navajo		northern
PI 218161	Navajo		northern
PI 476868	Taos Pueblo		northern
PI 213767	Unknown Pueblo		northern
PI 218135	Picuris Pueblo		northern
PI 218142	Picuris Pueblo		northern

Table 24: continued

Accession	Ethnic group	Racial assignment	Cluster ID (New Mexico)
PI 218149	Taos Pueblo		northern
PI 218152	Taos Pueblo		northern
NSL 67058	Hopi		northern
NSL 67059	Hopi		northern
PI 213739	Navajo		northern
PI 218134	Tesuque Pueblo		northern
PI 213737	Navajo		northern
PI 213729	White Mountain Apache		1
PI 474206	Mexico		1
PI 474209	Mexico		1
PI 490973	Mexico	dulnor	1
PI 218140	Acoma Pueblo		2
PI 218145	Cochiti Pueblo		2
Ames 22643	Hopi		3
PI 420247	Hopi (Shungopovi)		3
PI 218174	Hopi (Moencopi)		3
NSL 68323	Hopi		papago
PI 213741	Walapai		papago
NSL 68324	Hopi		papago
PI 485116	Mexico	crchih	papago
PI 218186	Mojave		papago
PI 218187	Mojave		papago
PI 420251	Pima-Maricopa	pimpap	papago
PI 484413	Mexico	apachi (crchih)	papago
PI 451716	Tohono O'odham	pimpap	papago
PI 213714	Tohono O'odham	pimpap	papago
PI 218179	Tohono O'odham		papago
PI 503563	Pima-Maricopa	pimpap	papago
PI 218185	Tohono O'odham		papago
PI 503573	Tohono O'odham	pimpap	papago
PI 484433	Mexico	gordo (crchih)	papago
PI 484482	Mexico	crchih (azul)	papago
PI 213730	White Mountain Apache		4
PI 213736	San Carlos Apache		4
PI 217411	Control (Mesquakie)	nnaff	4
PI 222285	Navajo	nnaff	5
NSL 2830	Mexico		6
PI 213757	Control (Quapaw)	seam8r	6
Ames 6048	Control (Cherokee)	seam8r	6
PI 213732	Control (Arapaho)		6

Table 24: continued

Accession	Ethnic group	Racial assignment	Cluster ID (New Mexico)
PI 217408	Control	nnaff	7
PI 213740	Navajo		8
Ames 19097	Control		cornbelt
Ames 26908	Control		cornbelt
PI 213712	Control	cornbd	cornbelt
PI 218154	San Felipe Pueblo		cornbelt
NSL 67055	Hopi		cornbelt
PI 213697	Control	cornbd	cornbelt
NSL 67062	Hopi		cornbelt
NSL 67063	Hopi		cornbelt
NSL 68329	Hopi		cornbelt
PI 213728	White Mountain Apache		cornbelt
PI 408705	Control	cornbd	cornbelt
NSL 67047	Hopi		southern dent
NSL 67048	Hopi	seamdt	southern dent
PI 218184	Tohono O'odham	seamdt	southern dent
PI 218191	Tohono O'odham	seamdt	southern dent
PI 218180	Tohono O'odham	seamdt	southern dent
PI 218183	Tohono O'odham	seamdt	southern dent
NSL 68335	Hopi		southern dent
PI 218181	Tohono O'odham	seamdt	southern dent
NSL 68336	Hopi		southern dent
PI 218182	Tohono O'odham	seamdt	southern dent
NSL 67049	Hopi	seamdt	southern dent
NSL 67051	Hopi		southern dent
NSL 67068	Hopi		southern dent
PI 218190	Tohono O'odham		southern dent
PI 218189	Tohono O'odham	seamdt	southern dent
PI 420252	Mexico		southern dent
PI 508270	Control (Arizona germplasm)		southern dent
PI 550563	Control (Arizona germplasm)		southern dent
PI 629147	Mexico	tuxnor	southern dent
NSL 67052	Hopi		southern dent
PI 311243	Mexico	seamdt	southern dent
PI 217405	Control	seamdt	southern dent
NSL 283388	Mexico	chapal	9
PI 490921	Mexico	revent	9
PI 420245	Mexico	chapal	9

Table 25: Combined accession means from the three environments

Accession	GDD5a	GDD5s	tiller	height	earheight	leaves	nodes	llength	circ
Ames 22643	1209	1280	6.27	90.43	30.77	12.32	6.95	79.53	62.83
Ames 26908	1485	1537	1.28	213.33	112.75	17.68	11.47	84.37	76.85
Ames 6048	1572	1652	1.90	190.30	99.41	17.84	11.10	78.15	72.45
Ames 19097	1457	1497	0.57	187.30	91.28	17.36	10.94	80.56	83.32
Zuni	1366	1447	2.98	195.70	77.05	15.11	8.74	102.01	82.30
NSL 2830	1643	1752	3.02	202.55	113.81	16.69	10.91	96.47	70.83
NSL 283388	1820	1957	3.58	224.35	139.59	17.77	12.38	96.46	71.13
NSL 67047	1791	1859	0.96	266.66	171.10	20.64	14.65	96.62	90.04
NSL 67048	1792	1823	1.15	262.98	165.37	20.47	14.25	96.69	94.95
NSL 67049	1864	1949	0.89	295.12	190.09	20.56	14.74	95.76	89.43
NSL 67051	1797	1947	0.91	283.17	200.98	20.36	14.22	91.07	87.68
NSL 67052	1585	1645	1.53	209.07	118.04	19.05	12.52	83.54	78.80
NSL 67053	1446	1508	2.89	211.15	101.54	16.51	10.18	96.79	78.44
NSL 67054	1458	1520	3.69	210.26	97.64	16.11	9.47	97.86	80.46
NSL 67055	1330	1425	1.56	194.96	98.92	16.93	10.91	81.78	75.76
NSL 67056	1372	1452	3.07	170.65	79.58	15.39	9.67	87.12	76.65
NSL 67057	1438	1556	3.74	168.87	72.60	14.95	9.45	91.58	74.86
NSL 67058	1316	1425	2.69	163.35	78.08	15.49	9.58	83.41	69.41
NSL 67059	1275	1381	2.56	172.99	78.92	15.68	9.79	84.18	68.15
NSL 67060	1283	1349	3.43	171.97	75.00	14.65	9.27	86.95	69.33
NSL 67061	1268	1373	3.60	179.92	83.23	15.22	9.50	83.05	70.61
NSL 67062	1477	1544	2.46	212.87	104.16	16.66	10.84	90.74	73.01
NSL 67063	1509	1545	1.73	222.84	113.33	17.52	11.10	89.19	74.68
NSL 67064	1481	1552	3.78	160.98	70.07	14.71	9.11	98.70	72.33
NSL 67065	1388	1480	3.02	193.46	86.69	15.77	9.52	95.02	84.06
NSL 67066	1389	1477	3.65	153.56	77.25	14.87	9.24	87.67	75.62
NSL 67068	1786	1839	0.85	273.27	176.71	21.02	14.94	89.21	92.50
NSL 68323	1171	1256	3.50	129.64	46.21	12.94	8.08	69.41	60.89
NSL 68324	1140	1224	3.74	137.28	48.54	12.54	8.26	72.22	59.74
NSL 68325	1450	1520	3.16	207.88	90.99	16.60	10.17	93.78	80.92
NSL 68326	1490	1553	3.51	181.13	69.93	14.89	8.53	95.96	80.27
NSL 68327	1496	1541	2.82	173.47	61.20	15.22	8.49	90.67	83.60
NSL 68329	1543	1598	2.00	217.28	126.74	17.78	12.54	88.32	76.32
NSL 68330	1481	1516	4.52	132.56	46.72	14.05	7.46	88.31	79.13
NSL 68331	1376	1446	4.25	144.70	57.98	14.10	8.35	90.87	77.86
NSL 68332	1441	1497	4.83	120.52	40.97	13.24	7.30	89.85	77.77
NSL 68334	1391	1439	4.66	117.46	37.83	13.11	7.23	91.29	79.96
NSL 68335	1728	1761	1.16	242.15	144.78	20.39	13.49	102.04	87.29
NSL 68336	1792	1793	1.58	240.94	158.52	19.74	13.89	88.07	81.78
PI 213697	1420	1502	1.49	173.72	84.95	16.31	9.99	81.90	73.49

Table 25: continued

Accession	GDD5a	GDD5s	tiller	height	earheight	leaves	nodes	llength	circ
PI 213712	1503	1588	0.94	190.02	93.46	18.84	11.42	87.68	83.66
PI 213714	1481	1546	3.08	188.18	85.18	15.75	9.82	80.04	62.15
PI 213728	1404	1480	2.70	171.18	78.09	15.80	9.59	75.54	67.13
PI 213729	1564	1664	2.94	188.36	65.18	14.32	8.46	93.50	73.92
PI 213730	1443	1527	2.54	123.53	47.92	13.34	7.91	79.10	70.44
PI 213732	1554	1696	4.00	163.70	85.45	14.63	9.71	86.07	69.72
PI 213733	1378	1466	4.33	115.21	36.51	12.90	6.99	86.69	77.65
PI 213734	1375	1439	4.02	103.11	45.38	13.11	7.83	85.20	74.61
PI 213735	1322	1412	3.55	119.77	43.93	13.22	7.53	86.94	79.92
PI 213736	1509	1533	4.26	147.20	56.49	13.49	8.49	80.98	65.68
PI 213737	1167	1228	2.95	140.36	43.75	12.77	7.17	76.50	77.09
PI 213738	1187	1282	2.64	119.65	36.04	12.29	7.02	76.88	83.86
PI 213739	1242	1340	2.63	145.26	59.12	14.83	8.48	76.28	66.95
PI 213740	1606	1759	3.39	154.77	73.27	15.70	10.16	76.12	67.90
PI 213741	1311	1366	2.48	126.57	55.93	13.77	8.70	69.21	63.02
PI 213757	1597	1688	2.90	184.65	96.96	16.37	10.51	94.38	72.84
PI 213767	1498	1562	3.16	166.34	75.17	16.06	9.90	87.79	74.14
PI 217405	1733	1860	1.30	209.70	120.47	17.95	11.86	91.18	85.25
PI 217408	1143	1241	3.62	125.84	36.54	12.33	7.37	68.72	67.59
PI 217411	1290	1436	4.05	118.50	43.65	13.78	7.58	73.66	67.70
PI 218130	1662	1698	3.54	214.66	107.30	17.43	10.95	105.50	84.00
PI 218131	1478	1531	3.21	201.11	90.02	16.48	10.00	97.87	83.97
PI 218133	1638	1724	4.35	202.82	106.74	16.82	10.16	99.94	93.69
PI 218134	1338	1465	3.29	166.07	75.35	15.43	9.52	79.71	66.59
PI 218135	1149	1283	3.44	136.89	43.14	12.97	7.47	79.25	78.89
PI 218136	1337	1431	5.27	108.19	38.34	12.52	7.26	89.55	76.63
PI 218137	1336	1424	3.12	181.82	69.60	15.68	9.41	101.03	78.50
PI 218138	1681	1736	2.95	212.88	106.67	17.05	10.66	100.56	94.04
PI 218139	1653	1788	4.16	218.93	100.86	17.00	10.17	108.50	91.57
PI 218140	1386	1519	4.05	165.61	82.35	14.60	9.43	85.01	68.63
PI 218141	1399	1470	3.77	194.08	79.76	14.87	9.00	93.61	80.53
PI 218142	1152	1260	2.74	139.15	46.45	13.69	7.60	82.53	80.53
PI 218143	1534	1593	3.64	202.17	97.92	16.40	9.80	109.50	81.30
PI 218144	1559	1618	3.24	218.18	99.29	17.09	9.98	99.96	87.72
PI 218145	1462	1519	3.24	182.12	77.87	16.21	9.00	95.66	75.98
PI 218146	1383	1460	3.63	175.70	74.59	14.97	8.99	93.94	81.60
PI 218147	1582	1675	3.92	208.57	103.68	16.69	10.23	101.43	91.24
PI 218148	1610	1686	3.65	215.14	109.37	16.87	10.54	102.23	88.73
PI 218149	1226	1248	2.79	147.05	53.25	13.23	7.71	80.53	78.30
PI 218150	1521	1584	3.61	185.02	88.35	15.81	10.04	102.68	87.53
PI 218151	1538	1644	3.77	185.62	83.41	14.91	9.30	98.36	82.31

Table 25: continued

Accession	GDD5a	GDD5s	tiller	height	earheight	leaves	nodes	llength	circ
PI 218152	1197	1305	2.61	146.81	52.66	14.77	8.42	78.94	77.71
PI 218153	1529	1611	3.51	195.87	92.61	15.83	9.97	103.28	76.70
PI 218154	1523	1579	2.47	223.53	114.99	17.88	11.42	95.72	84.24
PI 218155	1551	1592	1.97	207.78	101.52	17.14	10.53	100.81	89.54
PI 218156	1554	1634	2.82	222.18	106.72	16.39	10.26	108.04	82.75
PI 218157	1410	1509	3.07	199.61	88.07	16.12	10.01	102.68	82.19
PI 218158	1585	1662	3.27	236.11	117.23	16.14	10.51	107.37	89.30
PI 218159	1572	1654	3.40	214.74	101.30	16.02	10.18	114.83	88.16
PI 218160	1325	1388	4.66	121.94	39.00	13.20	7.33	91.90	74.48
PI 218161	1299	1359	4.98	132.51	43.31	13.22	7.95	89.85	81.62
PI 218162	1349	1431	4.35	148.44	52.29	13.81	8.38	93.75	79.54
PI 218163	1434	1513	5.09	146.98	60.62	13.43	8.25	91.15	73.04
PI 218164	1370	1411	4.69	135.16	46.77	13.34	7.72	94.89	76.52
PI 218165	1361	1434	4.00	124.15	45.85	12.80	7.62	91.92	75.56
PI 218166	1327	1399	4.93	128.85	47.43	13.16	8.23	94.73	73.90
PI 218167	1506	1592	3.40	188.33	83.49	15.50	9.29	102.11	96.34
PI 218168	1454	1530	3.42	180.70	80.57	14.61	9.01	96.79	80.66
PI 218169	1455	1578	3.40	182.11	82.60	15.51	9.62	105.41	87.62
PI 218170	1495	1568	4.43	185.76	81.74	15.10	8.98	106.79	77.85
PI 218171	1547	1660	2.81	218.53	112.96	17.20	11.05	101.19	88.53
PI 218172	1545	1636	2.91	226.09	111.46	17.18	10.65	99.61	82.10
PI 218173	1631	1668	3.74	221.24	110.56	17.02	10.51	109.82	88.13
PI 218174	1168	1204	4.55	95.60	22.85	11.91	6.58	70.91	70.93
PI 218175	1512	1550	4.93	154.91	68.72	14.11	8.75	98.11	78.22
PI 218176	1507	1517	4.42	155.43	65.62	14.47	8.53	98.15	87.70
PI 218178	1473	1522	3.76	144.78	57.58	14.25	8.55	94.19	87.07
PI 218179	1395	1470	3.57	182.16	76.03	14.51	9.41	85.12	64.50
PI 218180	1730	1753	0.98	231.28	142.57	17.86	12.91	87.95	80.08
PI 218181	1705	1742	1.05	235.17	143.43	18.38	12.60	97.62	81.93
PI 218182	1850	1908	0.46	259.39	171.60	20.56	14.72	89.47	86.83
PI 218183	1825	2029	0.71	253.98	145.05	19.01	12.70	91.54	91.78
PI 218184	1778	1849	0.72	263.88	164.88	20.18	13.80	93.96	90.38
PI 218185	1357	1428	3.82	171.02	77.43	14.72	9.61	86.96	62.41
PI 218186	1194	1293	3.59	142.21	49.42	13.91	8.16	72.83	65.83
PI 218187	1388	1436	3.24	147.15	59.75	14.20	9.20	74.94	65.81
PI 218188	1506	1563	3.37	209.33	104.64	16.81	10.26	96.46	75.79
PI 218189	1721	1787	1.10	223.58	141.82	20.56	14.26	87.69	87.48
PI 218190	1753	1768	1.14	242.86	155.98	19.85	13.83	93.42	90.44
PI 218191	1802	1892	0.38	265.02	167.22	20.40	14.56	96.58	102.25
PI 222285	1129	1171	3.96	80.92	18.37	10.49	5.90	61.63	60.70
PI 311229	1384	1470	4.50	134.16	54.18	13.90	8.34	99.98	79.83

Table 25: continued

Accession	GDD5a	GDD5s	tiller	height	earheight	leaves	nodes	llength	circ
PI 311243	1557	1664	1.44	228.29	134.78	19.48	13.13	85.20	78.57
PI 317674	1537	1573	4.55	154.47	57.20	15.78	9.21	92.36	87.12
PI 317675	1422	1501	4.16	116.19	43.26	14.13	8.10	81.87	85.34
PI 317678	1506	1571	4.43	135.66	53.12	15.47	9.10	86.13	82.50
PI 317679	1524	1605	4.21	139.48	54.94	14.82	8.71	91.43	87.67
PI 408705	1494	1541	2.33	184.53	92.88	16.90	10.27	83.67	73.43
PI 420245	1733	1777	2.75	199.29	122.64	17.56	12.40	86.86	69.99
PI 420247	1253	1356	5.67	108.01	36.22	12.62	7.45	83.52	72.55
PI 420248	1438	1504	4.39	118.16	45.94	12.99	7.87	81.30	72.49
PI 420250	1489	1529	4.44	129.92	52.12	13.18	7.80	96.18	78.75
PI 420251	1234	1284	4.29	142.19	44.75	12.64	7.57	71.69	61.88
PI 420252	1766	1939	2.18	229.18	142.80	19.55	13.34	91.67	84.97
PI 451716	1260	1307	4.10	134.03	55.91	13.38	8.72	72.95	64.78
PI 474206	1743	2010	4.29	226.99	140.50	17.66	11.67	96.77	72.44
PI 474209	1702	1849	4.91	214.86	120.71	16.12	10.93	99.29	69.46
PI 476868	1215	1340	3.38	147.91	51.41	13.73	7.62	84.85	77.56
PI 476869	1398	1483	4.00	120.94	43.91	13.28	7.75	80.84	78.43
PI 476870	1430	1508	4.11	133.87	48.53	13.76	8.00	92.60	84.49
PI 484413	1169	1258	4.48	148.22	59.17	12.04	7.90	71.44	60.40
PI 484433	1347	1535	4.65	185.49	89.28	13.58	9.17	77.66	68.48
PI 484482	1366	1511	4.77	197.09	110.89	14.33	10.35	78.86	63.89
PI 485116	1154	1285	4.48	157.77	71.44	11.95	7.83	72.16	64.41
PI 490921	1836	2077	3.60	196.92	127.79	16.47	11.26	100.63	68.94
PI 490973	1776	1827	5.39	241.96	137.97	16.51	11.65	92.10	71.96
PI 503562	1387	1515	5.03	130.37	50.98	13.35	7.98	89.73	80.87
PI 503563	1319	1380	3.97	175.46	70.48	14.74	9.54	83.16	68.07
PI 503564	1425	1482	4.51	132.75	52.27	13.73	8.10	90.47	82.88
PI 503565	1435	1494	4.76	142.33	53.00	13.83	8.12	102.39	84.01
PI 503566	1430	1481	4.70	136.54	54.45	13.53	8.18	97.26	77.98
PI 503567	1386	1459	4.84	134.27	50.08	13.27	8.26	90.77	78.52
PI 503568	1415	1494	4.20	141.71	52.47	13.64	7.86	96.08	76.58
PI 503573	1253	1357	5.00	149.60	59.88	13.25	8.94	74.68	60.50
PI 508270	1730	1773	1.52	264.35	165.44	18.84	13.18	88.57	78.33
PI 550563	1617	1646	2.11	240.36	137.06	17.84	12.17	90.61	75.61
PI 629147	1903	2023	0.76	291.50	197.52	20.89	15.14	90.58	87.59

Table 25: continued

Accession	lwidth	branch	spike	branching	tassel	husk	shank	row	kernels
Ames 22643	7.09	11.72	24.40	11.16	40.53	9.95	9.39	13.94	31.58
Ames 26908	10.98	14.56	30.17	16.93	54.03	10.06	15.44	17.02	48.50
Ames 6048	8.85	17.13	22.38	16.89	41.22	10.68	13.78	8.40	29.39
Ames 19097	11.33	8.37	29.71	12.99	52.75	9.72	16.90	15.70	49.82
Zuni	9.73	20.16	29.38	16.37	50.30	14.10	16.23	15.86	44.63
NSL 2830	9.26	13.65	29.26	19.91	53.79	11.17	19.34	8.13	41.41
NSL 283388	8.76	16.89	27.28	15.92	50.59	11.85	15.48	10.84	32.68
NSL 67047	12.04	19.98	30.20	18.85	52.35	14.23	13.43	15.27	37.49
NSL 67048	11.84	20.23	27.18	17.85	49.52	14.44	12.48	15.71	38.05
NSL 67049	11.50	19.64	27.20	18.06	50.25	14.19	11.05	17.06	39.51
NSL 67051	10.86	21.31	27.16	19.51	50.29	13.83	11.70	15.78	43.10
NSL 67052	12.04	19.94	24.51	16.03	42.38	12.39	11.29	14.67	41.07
NSL 67053	10.31	19.43	26.59	18.27	50.90	13.03	15.46	14.43	42.03
NSL 67054	9.94	18.38	29.30	17.42	51.84	13.23	15.94	14.67	43.67
NSL 67055	10.43	19.99	26.02	16.55	49.56	11.73	12.81	14.33	40.99
NSL 67056	9.32	16.17	27.68	14.04	47.62	12.19	14.27	13.68	45.45
NSL 67057	9.23	12.73	26.88	12.77	45.32	11.23	13.79	12.86	37.26
NSL 67058	8.66	13.80	25.35	13.38	42.96	12.01	15.03	13.57	34.87
NSL 67059	9.15	14.93	25.58	12.85	43.13	13.53	14.67	13.31	35.32
NSL 67060	9.37	17.22	27.03	15.64	47.83	12.25	13.83	11.77	43.10
NSL 67061	9.09	19.11	27.12	15.61	47.24	13.60	15.83	13.01	41.79
NSL 67062	9.50	17.47	30.15	16.47	51.77	9.82	12.06	12.51	38.07
NSL 67063	10.55	18.97	28.77	15.19	48.91	12.71	12.53	13.03	42.13
NSL 67064	8.97	11.34	28.52	12.69	46.06	10.36	11.56	13.51	37.43
NSL 67065	10.35	18.25	27.24	16.29	50.00	14.16	16.81	15.30	41.71
NSL 67066	9.25	13.85	27.56	13.50	44.47	11.32	12.65	13.44	37.03
NSL 67068	10.68	21.61	25.15	20.33	50.45	11.73	9.97	16.79	41.98
NSL 68323	7.91	12.51	28.20	9.79	41.55	9.02	10.56	12.94	33.97
NSL 68324	7.42	9.66	28.78	8.88	43.06	9.39	10.79	13.47	32.79
NSL 68325	10.26	19.59	26.78	18.06	51.51	11.85	10.75	14.53	46.77
NSL 68326	9.20	12.53	29.84	12.76	48.56	10.79	13.55	14.31	42.19
NSL 68327	9.31	10.85	28.96	13.80	50.29	12.22	16.54	13.98	41.18
NSL 68329	10.27	15.70	27.69	14.91	45.70	11.51	12.73	11.87	40.71
NSL 68330	7.78	10.64	28.78	10.49	40.98	16.38	10.43	14.99	34.76
NSL 68331	8.49	15.86	25.99	14.01	44.55	11.32	9.90	13.30	36.33
NSL 68332	7.66	8.92	29.49	11.42	42.33	11.53	14.28	13.60	30.16
NSL 68334	6.89	12.11	29.75	13.14	43.88	9.24	9.46	12.37	32.95
NSL 68335	11.55	19.57	29.05	16.18	46.84	16.05	11.49	15.64	38.93
NSL 68336	11.67	18.69	24.98	16.85	45.01	12.27	10.17	13.30	39.64
PI 213697	10.23	15.52	28.15	14.97	49.49	10.16	10.85	15.20	43.88

Table 25: continued

Accession	lwidth	branch	spike	branching	tassel	husk	shank	row	kernels
PI 213712	11.15	22.97	27.65	19.76	52.71	12.99	14.68	15.70	45.40
PI 213714	8.86	14.42	26.87	13.52	48.02	13.88	12.69	12.20	30.57
PI 213728	9.10	14.75	31.01	14.76	47.75	11.31	8.51	15.76	38.94
PI 213729	8.16	16.36	24.98	16.60	50.77	13.33	9.72	13.41	37.10
PI 213730	6.55	14.14	20.01	11.76	35.66	8.79	8.78	11.43	29.96
PI 213732	9.21	19.54	21.90	16.47	40.72	10.59	9.13	10.42	26.51
PI 213733	8.02	12.62	25.74	11.80	40.16	13.30	10.90	14.99	35.80
PI 213734	8.28	13.26	26.48	11.08	40.18	9.41	8.41	14.20	29.47
PI 213735	7.81	18.73	25.26	14.25	42.32	10.59	14.44	12.93	35.29
PI 213736	7.42	9.16	26.93	11.52	45.34	6.80	8.03	9.40	24.37
PI 213737	7.72	12.08	24.12	10.45	39.38	12.04	15.06	11.65	32.95
PI 213738	7.83	14.85	23.95	14.44	42.19	12.96	15.81	13.18	36.86
PI 213739	8.74	17.71	23.10	14.63	44.14	13.83	10.34	13.91	34.79
PI 213740	9.49	20.70	19.59	20.53	47.83	11.81	14.75	8.18	34.70
PI 213741	7.81	6.54	25.35	6.65	35.57	10.53	9.61	12.46	23.62
PI 213757	9.67	14.47	29.56	15.47	49.72	10.89	16.45	8.34	37.72
PI 213767	9.40	17.28	25.48	13.76	43.22	15.39	11.61	12.12	29.65
PI 217405	11.57	20.65	25.10	15.52	43.22	12.93	11.52	17.26	34.79
PI 217408	7.58	13.57	24.15	13.58	47.55	10.12	17.28	8.14	35.96
PI 217411	7.47	13.89	25.34	11.47	39.66	10.97	10.66	8.43	23.88
PI 218130	9.49	16.73	31.18	14.68	49.08	14.65	16.65	17.98	44.43
PI 218131	9.91	19.28	26.55	15.41	46.14	13.61	16.06	13.78	44.94
PI 218133	10.38	23.39	25.89	16.88	45.94	14.72	14.91	18.48	42.69
PI 218134	9.06	19.96	26.65	16.48	47.39	13.45	11.80	14.21	36.49
PI 218135	7.54	14.96	25.17	13.80	44.89	13.72	14.84	14.75	35.02
PI 218136	8.17	12.25	25.41	12.82	42.87	11.11	9.03	13.24	31.93
PI 218137	8.83	15.67	31.19	14.62	50.89	14.55	12.44	14.24	41.79
PI 218138	10.63	21.90	29.26	15.93	46.44	12.16	15.88	16.50	40.07
PI 218139	10.22	21.41	28.09	17.98	50.17	15.60	16.13	15.17	48.29
PI 218140	8.53	18.26	29.63	14.04	50.92	10.36	15.84	15.40	38.48
PI 218141	9.39	16.37	26.73	16.44	52.11	12.99	14.85	13.91	41.27
PI 218142	7.72	16.99	27.74	13.86	46.21	13.71	15.58	12.98	36.14
PI 218143	9.73	18.59	27.83	16.10	49.22	14.82	14.00	15.56	46.27
PI 218144	10.45	16.99	30.44	14.38	48.26	13.73	15.00	17.98	43.04
PI 218145	8.74	18.85	25.91	15.88	46.48	14.08	13.84	15.15	49.93
PI 218146	9.37	16.59	28.65	15.29	49.28	12.35	14.69	14.69	40.55
PI 218147	10.31	21.07	28.39	16.33	47.22	14.40	18.40	16.11	42.34
PI 218148	11.10	16.72	26.78	15.50	46.77	12.29	12.96	16.97	46.01
PI 218149	8.87	17.74	27.04	14.12	45.19	12.84	17.37	12.76	38.15
PI 218150	10.23	21.45	28.19	16.72	49.43	11.70	14.84	14.70	46.91
PI 218151	9.47	15.93	30.30	15.72	51.14	13.64	14.98	15.74	40.50

Table 25: continued

Accession	lwidth	branch	spike	branching	tassel	husk	shank	row	kernels
PI 218152	8.61	18.43	25.47	13.75	44.10	15.87	13.75	13.27	38.69
PI 218153	9.32	16.86	28.62	17.61	50.21	12.21	14.75	12.91	49.25
PI 218154	11.33	21.83	28.28	17.59	50.48	12.06	16.96	16.29	47.55
PI 218155	11.79	19.06	30.86	18.49	53.25	13.84	17.98	14.21	43.27
PI 218156	9.32	18.31	27.24	16.86	50.28	14.24	13.99	14.94	47.60
PI 218157	9.77	19.53	27.60	16.79	50.44	14.93	13.91	16.04	43.20
PI 218158	10.85	20.46	29.47	17.43	49.98	12.18	16.43	14.67	47.81
PI 218159	9.91	19.14	28.69	18.92	52.20	12.54	17.91	15.07	46.75
PI 218160	7.45	18.90	26.29	14.51	43.70	10.71	10.58	14.19	35.68
PI 218161	7.56	15.00	27.91	13.92	45.10	10.14	12.79	13.84	35.20
PI 218162	8.50	15.09	28.93	11.85	43.17	9.18	11.76	13.64	37.41
PI 218163	7.89	12.95	29.17	11.56	44.09	10.33	10.16	14.13	36.78
PI 218164	8.45	11.89	29.20	12.56	46.33	10.13	11.97	13.87	36.48
PI 218165	8.06	15.60	30.17	14.15	46.98	9.12	9.72	13.13	37.70
PI 218166	7.79	13.49	28.22	12.60	45.22	9.51	9.86	13.33	39.58
PI 218167	10.11	21.01	33.06	18.35	54.74	12.20	15.93	14.18	43.94
PI 218168	9.06	19.62	26.64	17.21	50.78	12.56	17.01	15.30	36.84
PI 218169	9.95	16.67	33.94	16.25	54.69	15.91	16.03	14.47	47.18
PI 218170	9.05	15.13	32.00	14.04	49.42	14.24	14.94	14.81	41.60
PI 218171	9.97	19.13	29.85	16.89	49.92	11.87	14.19	13.83	44.20
PI 218172	9.70	16.85	31.52	16.04	51.31	13.79	14.70	15.55	43.82
PI 218173	10.01	19.23	32.52	18.31	52.55	12.54	15.13	14.67	46.19
PI 218174	6.92	11.14	22.34	7.88	32.88	10.16	9.08	12.56	30.21
PI 218175	9.28	14.84	29.62	13.11	46.25	11.13	12.60	13.79	40.00
PI 218176	10.16	14.00	28.86	11.85	42.73	11.76	14.43	12.88	37.78
PI 218178	9.30	15.72	30.66	12.94	45.35	12.56	12.71	14.37	35.08
PI 218179	8.76	12.52	28.36	12.28	44.95	10.21	12.07	12.86	37.18
PI 218180	10.95	15.90	28.61	16.67	47.70	13.21	14.45	16.13	37.97
PI 218181	10.83	18.39	30.63	18.21	53.13	11.93	14.58	13.80	38.14
PI 218182	11.65	20.79	26.63	18.81	47.29	14.16	12.90	14.06	38.08
PI 218183	11.29	17.19	31.37	15.70	49.53	14.14	13.51	16.41	39.54
PI 218184	10.91	20.13	28.29	18.57	49.72	15.41	12.95	15.76	38.14
PI 218185	8.56	13.62	30.61	11.73	47.40	9.93	9.74	12.00	35.72
PI 218186	7.86	11.21	27.36	9.51	39.80	10.21	10.61	10.83	32.92
PI 218187	9.13	11.17	28.11	8.04	39.00	7.85	7.90	10.47	36.01
PI 218188	9.62	17.11	27.57	16.11	48.90	12.50	16.68	13.62	48.59
PI 218189	10.98	20.31	24.86	17.28	43.18	12.67	11.36	17.18	38.72
PI 218190	10.95	21.42	26.38	19.08	47.28	14.34	12.68	14.69	39.20
PI 218191	11.78	17.32	30.54	18.35	53.00	14.98	15.51	14.60	37.64
PI 222285	4.62	10.60	25.93	8.97	35.97	6.53	8.49	10.56	25.63
PI 311229	8.32	19.10	25.33	15.80	43.39	10.73	11.08	15.18	36.89

Table 25: continued

Accession	lwidth	branch	spike	branching	tassel	husk	shank	row	kernels
PI 311243	10.67	22.13	25.69	19.15	47.55	12.41	13.89	15.09	44.52
PI 317674	9.56	16.35	25.36	12.68	41.44	12.93	14.13	12.79	37.53
PI 317675	8.76	12.66	24.24	10.84	38.51	14.69	11.06	12.66	34.08
PI 317678	8.35	15.51	25.91	12.35	42.07	13.17	12.26	11.72	38.05
PI 317679	9.14	16.20	25.82	13.83	42.58	12.44	13.53	12.56	38.45
PI 408705	10.08	16.28	28.28	14.00	47.12	10.69	17.31	19.67	42.98
PI 420245	8.34	15.40	22.43	15.99	46.06	10.91	12.01	11.56	31.12
PI 420247	7.54	13.91	24.25	12.91	41.55	12.56	9.63	13.67	29.81
PI 420248	7.64	14.88	25.55	13.90	42.20	10.14	12.14	13.74	30.71
PI 420250	9.35	14.01	29.28	13.07	43.43	9.71	9.92	13.01	37.39
PI 420251	7.20	10.43	27.60	8.79	41.26	10.40	10.21	12.44	29.89
PI 420252	10.51	17.62	32.96	14.05	49.17	12.83	14.60	14.64	36.09
PI 451716	8.58	11.76	24.43	7.47	33.85	10.36	9.97	13.98	32.56
PI 474206	9.02	18.97	29.88	18.09	52.10	11.42	18.22	11.23	35.30
PI 474209	9.07	14.72	34.52	15.83	56.74	10.69	16.29	13.10	37.59
PI 476868	7.91	14.79	29.21	13.94	48.84	14.89	15.76	12.71	38.12
PI 476869	8.31	18.16	27.21	13.38	43.72	10.56	10.00	14.06	35.32
PI 476870	9.17	13.76	27.84	10.80	39.86	10.52	11.40	13.14	35.88
PI 484413	8.25	6.79	27.17	6.96	41.31	8.83	11.55	11.36	30.78
PI 484433	9.67	12.32	31.41	11.49	47.42	8.65	14.24	12.85	33.20
PI 484482	8.90	9.92	31.50	9.99	44.52	8.85	12.67	11.30	35.95
PI 485116	8.00	7.84	30.93	7.23	44.38	9.37	14.23	13.24	33.64
PI 490921	7.99	20.61	33.35	13.16	48.16	10.90	9.49	14.28	34.40
PI 490973	8.96	16.46	26.68	15.09	45.02	11.82	16.42	12.40	33.46
PI 503562	8.45	15.42	27.02	14.20	44.95	10.81	10.08	13.58	38.14
PI 503563	8.57	14.94	31.66	13.08	48.97	10.36	10.66	12.75	36.80
PI 503564	8.39	16.14	26.53	13.60	43.09	13.03	11.75	15.38	37.31
PI 503565	8.53	13.89	30.52	14.24	47.27	11.98	13.62	13.24	39.48
PI 503566	9.27	18.58	29.60	14.95	47.84	9.83	11.93	14.61	37.65
PI 503567	8.15	14.18	27.85	11.70	42.14	10.65	9.52	12.64	34.25
PI 503568	8.54	15.93	31.52	15.69	50.58	9.81	15.12	13.42	38.71
PI 503573	7.85	12.82	27.97	11.79	44.20	9.89	12.93	11.78	36.08
PI 508270	10.88	19.78	28.35	15.75	49.24	12.97	14.17	15.62	40.10
PI 550563	10.87	21.80	28.25	16.50	46.38	12.90	11.08	14.28	42.04
PI 629147	9.81	20.20	29.02	18.61	49.61	14.84	18.59	15.01	36.23

Table 25: continued

Accession	elength	dia12	eweight	kthick	kwidth	klength	kw	kv	weightear
Ames 22643	15.59	34.09	72.91	37.31	73.30	92.75	14.51	12.78	63.58
Ames 26908	23.35	50.04	317.64	40.88	81.22	128.94	32.42	25.33	257.92
Ames 6048	16.15	35.23	81.41	54.60	110.97	103.65	36.56	33.67	65.90
Ames 19097	22.65	48.91	256.37	38.08	83.83	136.99	32.12	26.44	230.86
Zuni	25.16	41.26	210.00	47.73	82.86	105.85	25.67	23.22	166.14
NSL 2830	25.98	33.67	132.34	48.73	113.27	96.92	34.17	28.33	106.12
NSL 283388	15.81	27.03	47.60	39.25	70.13	73.23	9.76	8.57	51.80
NSL 67047	19.38	51.30	203.57	43.03	95.77	120.58	29.44	26.11	150.73
NSL 67048	18.75	52.43	214.80	40.17	92.49	125.10	28.42	24.56	171.12
NSL 67049	17.43	52.66	183.66	35.33	87.88	126.99	22.06	20.67	140.94
NSL 67051	20.27	49.32	220.35	37.96	89.79	123.09	25.11	21.67	171.03
NSL 67052	19.18	51.26	249.80	38.43	94.37	136.69	31.23	26.44	188.51
NSL 67053	24.24	42.95	218.16	46.83	87.22	113.31	29.29	25.67	178.07
NSL 67054	24.38	41.00	203.73	48.03	86.66	106.77	27.44	24.89	158.13
NSL 67055	21.08	48.52	247.30	42.82	96.82	122.78	35.46	29.44	190.31
NSL 67056	21.93	40.31	181.08	41.01	85.74	107.71	25.70	22.00	153.44
NSL 67057	20.10	41.42	154.20	49.12	96.74	107.52	30.81	27.78	127.23
NSL 67058	17.52	39.23	135.87	42.80	83.71	103.41	25.98	21.67	111.24
NSL 67059	18.57	40.62	159.13	41.90	86.86	106.94	28.04	23.00	127.58
NSL 67060	22.57	39.15	180.02	42.98	93.11	106.50	29.57	24.00	145.52
NSL 67061	21.26	38.31	170.56	43.74	84.15	99.21	25.83	20.56	140.91
NSL 67062	22.00	45.33	210.98	45.55	103.27	117.09	35.68	30.78	174.23
NSL 67063	22.46	45.90	223.59	44.88	100.99	120.18	34.10	31.22	182.11
NSL 67064	19.71	41.05	154.42	46.87	92.31	105.54	29.24	26.11	120.77
NSL 67065	23.87	39.49	194.81	47.95	79.79	96.83	25.60	22.11	151.53
NSL 67066	20.48	44.25	176.02	48.59	95.29	110.83	31.98	28.38	142.72
NSL 67068	21.26	52.96	245.42	40.42	90.81	130.77	29.24	26.00	198.11
NSL 68323	20.75	34.55	105.60	50.96	83.82	89.71	22.52	20.22	86.61
NSL 68324	19.12	36.93	119.36	49.25	85.96	99.30	25.76	23.33	101.39
NSL 68325	24.37	43.74	217.01	44.57	88.98	107.23	26.54	24.56	169.66
NSL 68326	22.75	41.22	187.26	45.73	88.13	112.68	26.24	24.00	157.61
NSL 68327	22.46	40.01	175.13	47.17	87.41	105.17	25.81	22.88	150.76
NSL 68329	22.41	42.48	171.78	46.07	102.25	113.09	31.34	29.11	140.19
NSL 68330	19.41	40.20	140.38	45.50	84.32	106.16	25.59	23.43	120.41
NSL 68331	20.63	38.49	135.49	48.62	87.91	101.43	25.52	23.22	114.64
NSL 68332	17.28	39.64	109.39	48.71	86.62	98.25	25.14	22.78	90.99
NSL 68334	18.73	38.77	119.33	49.95	93.14	104.34	28.25	27.13	103.18
NSL 68335	20.35	48.45	216.34	43.33	91.60	128.29	30.51	26.44	178.03
NSL 68336	18.97	49.87	201.65	38.72	101.16	118.97	30.57	26.00	159.03
PI 213697	22.86	45.96	215.26	42.83	88.56	115.74	30.04	25.00	172.91

Table 25: continued

Accession	elength	dia12	eweight	kthick	kwidth	klength	kw	kv	weightear
PI 213712	21.15	48.41	264.98	40.25	85.91	133.91	32.00	26.11	219.16
PI 213714	18.85	34.10	99.38	49.60	87.18	92.08	24.13	22.11	79.61
PI 213728	18.73	44.11	181.45	39.27	81.19	115.59	25.13	21.38	146.73
PI 213729	20.69	39.82	130.76	49.07	88.99	94.03	25.93	23.11	107.96
PI 213730	15.96	34.85	85.49	44.24	90.43	95.84	22.86	21.50	67.46
PI 213732	16.68	40.42	101.13	46.10	109.09	105.69	31.81	30.43	76.12
PI 213733	19.71	34.91	105.94	46.67	72.55	90.80	19.06	16.00	88.36
PI 213734	17.15	37.25	100.89	51.56	79.77	93.15	21.95	19.89	93.00
PI 213735	20.43	38.39	133.71	52.12	92.92	99.99	27.88	25.78	113.09
PI 213736	15.22	31.64	52.69	48.43	90.40	87.21	20.56	20.11	47.97
PI 213737	18.88	37.14	124.25	44.51	93.03	100.18	26.06	23.33	98.49
PI 213738	23.37	37.53	136.59	49.78	83.77	96.81	24.10	22.56	117.31
PI 213739	18.58	40.14	143.20	44.38	85.76	100.74	23.46	20.78	112.24
PI 213740	18.44	28.71	68.24	43.31	87.39	78.79	18.91	16.67	50.53
PI 213741	16.59	34.32	63.60	55.92	87.53	87.20	22.57	22.22	62.37
PI 213757	20.51	35.04	120.73	42.69	106.12	97.88	31.09	25.75	90.50
PI 213767	18.70	41.11	130.80	50.58	97.06	95.57	30.47	27.22	99.52
PI 217405	16.18	55.11	181.82	38.13	87.63	146.02	24.91	23.56	151.90
PI 217408	19.68	34.20	105.89	47.29	110.43	92.60	32.10	26.33	84.44
PI 217411	14.08	32.83	54.68	46.21	99.16	88.47	26.13	22.56	57.93
PI 218130	22.30	44.13	202.01	43.32	80.09	104.54	21.78	20.33	156.58
PI 218131	23.36	42.76	209.89	43.52	92.02	110.43	28.43	25.44	168.71
PI 218133	23.27	48.62	228.75	46.43	86.13	112.96	26.57	24.86	198.30
PI 218134	17.58	43.68	140.66	38.75	87.61	102.13	22.39	18.67	110.80
PI 218135	20.03	43.60	158.56	48.56	92.05	99.79	25.44	24.33	120.76
PI 218136	17.81	35.57	96.27	47.11	79.46	93.08	20.14	18.22	80.63
PI 218137	23.73	40.26	184.16	48.54	86.78	103.60	25.92	23.44	143.54
PI 218138	23.04	49.98	225.38	46.99	96.74	107.11	29.01	27.13	199.70
PI 218139	27.19	44.30	251.18	48.41	90.64	110.59	27.06	25.44	193.43
PI 218140	19.43	34.35	123.69	41.21	65.67	99.26	18.21	13.38	101.90
PI 218141	21.62	42.46	194.53	44.09	89.95	106.42	28.88	24.33	154.93
PI 218142	21.29	41.79	142.47	50.65	96.56	98.80	29.23	25.44	101.60
PI 218143	24.92	40.21	202.90	46.67	80.44	106.45	25.22	22.78	162.09
PI 218144	23.32	47.53	243.21	48.31	86.54	111.51	27.02	24.38	189.94
PI 218145	24.31	36.49	157.86	42.63	73.11	96.74	19.72	17.44	136.32
PI 218146	22.02	40.74	157.84	46.32	86.09	100.82	24.81	22.88	135.94
PI 218147	24.45	44.20	221.50	46.03	87.99	109.60	27.39	25.33	167.17
PI 218148	25.40	46.70	261.90	46.37	85.56	108.15	26.04	23.44	204.44
PI 218149	21.97	41.63	174.92	48.27	95.81	103.78	32.07	26.44	143.86
PI 218150	23.78	40.65	190.82	42.91	84.16	106.17	23.58	21.88	150.92
PI 218151	22.69	42.32	191.71	46.23	85.59	105.27	24.33	22.22	150.87

Table 25: continued

Accession	elength	dia12	eweight	kthick	kwidth	klength	kw	kv	weightear
PI 218152	22.22	43.22	191.12	47.82	97.32	102.76	29.05	25.25	143.21
PI 218153	25.28	35.49	160.79	44.25	81.04	96.15	21.04	19.11	128.77
PI 218154	25.00	47.69	285.60	42.70	87.50	121.08	31.08	25.67	230.96
PI 218155	24.46	42.48	218.82	48.28	87.84	109.29	29.16	24.44	165.98
PI 218156	24.49	40.72	189.90	44.14	82.13	103.70	22.34	20.67	148.40
PI 218157	23.22	42.63	188.74	44.82	82.10	106.54	23.88	21.56	163.40
PI 218158	27.91	41.44	220.50	50.00	88.81	102.36	26.56	24.67	169.32
PI 218159	27.27	43.14	232.77	48.01	88.23	107.54	26.54	24.25	183.81
PI 218160	21.02	40.85	150.57	48.58	85.27	102.06	25.49	23.33	126.28
PI 218161	20.93	39.86	148.33	51.36	86.00	100.45	26.97	24.00	120.97
PI 218162	20.72	40.84	155.07	46.39	87.91	101.02	25.03	23.00	121.89
PI 218163	19.79	38.77	135.97	43.37	82.84	101.83	22.71	21.56	114.80
PI 218164	20.58	39.66	148.70	46.94	83.44	101.86	24.70	22.44	122.34
PI 218165	20.99	37.93	141.06	47.22	85.69	102.24	25.74	23.22	117.48
PI 218166	21.96	37.57	145.56	46.93	85.73	105.84	24.20	22.67	125.56
PI 218167	27.72	47.36	269.50	51.68	100.41	113.22	34.86	32.56	209.53
PI 218168	21.64	40.13	168.71	49.60	82.16	102.57	25.31	22.67	133.22
PI 218169	27.16	43.97	252.36	47.30	91.07	109.65	28.52	26.33	196.59
PI 218170	23.88	39.35	180.34	48.69	83.26	105.04	23.90	22.56	142.66
PI 218171	24.41	48.92	270.90	45.38	99.86	116.86	33.11	30.00	208.94
PI 218172	24.65	50.80	276.15	47.75	96.72	119.94	33.75	29.67	210.19
PI 218173	27.20	43.37	248.60	51.32	90.02	108.18	28.74	27.00	189.31
PI 218174	14.90	36.47	88.48	39.81	84.78	102.16	20.46	18.00	75.11
PI 218175	22.57	40.23	169.83	47.69	87.21	106.46	26.30	23.78	136.01
PI 218176	22.24	43.28	181.64	50.56	100.29	109.00	32.61	29.63	148.49
PI 218178	20.44	46.86	192.66	47.04	94.51	113.65	31.76	29.22	160.32
PI 218179	20.57	35.53	120.41	46.10	83.53	96.38	21.73	19.89	101.33
PI 218180	18.37	49.68	217.61	40.20	87.71	119.47	28.58	23.33	171.88
PI 218181	19.56	47.21	199.27	42.61	95.33	119.22	29.79	25.33	167.05
PI 218182	18.99	48.78	180.38	41.49	94.16	114.93	26.33	23.44	134.98
PI 218183	20.16	49.93	181.36	39.84	87.81	121.17	23.78	22.00	136.14
PI 218184	20.33	50.32	217.86	42.17	93.83	121.29	28.80	25.22	166.48
PI 218185	18.82	34.30	107.57	44.65	84.38	95.90	22.46	19.56	91.51
PI 218186	18.81	32.48	90.11	50.07	90.42	92.03	24.50	22.22	79.04
PI 218187	20.88	35.25	112.63	47.73	94.63	97.94	26.60	24.44	93.70
PI 218188	25.33	39.21	195.66	45.35	82.75	98.17	25.20	20.78	147.12
PI 218189	15.91	50.09	191.78	33.71	83.04	127.66	23.63	20.33	154.68
PI 218190	18.72	47.69	194.55	38.15	89.12	119.48	26.94	23.11	154.02
PI 218191	19.52	50.77	202.38	40.06	96.30	125.03	27.68	24.67	151.18
PI 222285	14.92	34.45	60.16	49.82	89.68	88.84	24.13	22.13	56.65
PI 311229	19.48	41.21	135.49	46.05	83.65	101.23	22.20	20.67	109.44

Table 25: continued

Accession	elength	dia12	eweight	kthick	kwidth	klength	kw	kv	weightear
PI 311243	19.27	46.73	232.41	36.32	86.86	134.42	30.12	24.67	195.18
PI 317674	21.89	40.44	158.09	48.97	93.48	102.98	27.42	25.78	126.92
PI 317675	19.53	37.68	112.03	47.07	91.27	102.62	24.01	22.89	103.70
PI 317678	21.47	37.89	129.17	48.31	93.41	97.97	22.80	21.88	110.73
PI 317679	22.35	39.50	155.21	47.83	92.96	105.39	27.27	25.56	125.91
PI 408705	19.00	48.55	237.82	37.23	72.43	126.60	23.58	20.22	198.54
PI 420245	14.77	30.17	65.45	38.05	72.57	84.39	15.36	13.22	55.06
PI 420247	15.02	35.24	78.50	37.13	76.89	95.79	16.52	14.44	71.44
PI 420248	18.37	40.06	127.59	51.46	86.71	96.91	25.71	24.13	108.69
PI 420250	22.49	38.79	125.81	51.02	86.38	93.12	21.46	20.22	114.53
PI 420251	16.78	33.60	93.38	45.16	82.87	95.33	22.52	19.67	75.72
PI 420252	18.02	40.51	127.03	41.33	79.07	99.29	18.78	15.88	100.64
PI 451716	17.53	35.23	103.30	42.91	77.72	95.97	19.68	17.44	89.79
PI 474206	19.91	36.97	100.96	46.13	96.94	96.50	22.22	21.56	93.10
PI 474209	22.12	34.26	105.85	49.53	80.75	85.63	20.82	17.11	90.14
PI 476868	23.79	38.80	166.00	51.10	90.44	96.31	26.84	24.11	129.96
PI 476869	19.27	37.14	115.58	44.54	80.19	98.30	21.26	19.44	102.60
PI 476870	20.98	43.92	175.82	50.80	99.27	107.02	31.83	29.63	151.01
PI 484413	17.83	32.55	96.50	46.41	83.29	98.49	25.07	21.56	78.48
PI 484433	19.82	39.46	147.84	50.14	92.18	115.03	31.56	27.88	124.16
PI 484482	22.02	37.74	152.13	49.62	95.34	112.09	34.27	29.22	123.82
PI 485116	19.90	38.23	147.55	50.47	87.46	105.45	30.27	26.00	118.16
PI 490921	17.38	27.91	53.15	37.82	60.04	76.41	11.09	9.44	54.60
PI 490973	19.75	34.58	82.86	46.10	83.60	90.24	17.94	15.67	80.04
PI 503562	21.18	36.01	135.98	49.40	82.18	97.83	24.92	21.89	126.49
PI 503563	20.01	33.84	117.21	46.44	80.07	95.11	21.70	18.89	105.43
PI 503564	20.72	40.58	152.76	47.26	83.30	101.42	24.34	21.56	129.67
PI 503565	22.45	39.59	163.48	47.39	89.58	104.73	26.49	23.78	135.50
PI 503566	21.34	36.99	135.19	47.26	79.68	98.18	21.26	19.67	115.10
PI 503567	19.16	40.89	141.87	47.97	96.71	106.22	29.79	27.44	134.00
PI 503568	21.56	38.43	155.28	49.68	85.15	101.88	27.63	24.44	129.69
PI 503573	20.16	33.18	104.79	48.28	83.17	90.54	21.99	20.00	83.19
PI 508270	19.16	45.79	183.82	37.95	81.93	116.77	24.20	19.83	142.50
PI 550563	19.42	42.84	184.76	38.24	84.39	113.86	25.04	21.00	157.26
PI 629147	18.14	42.31	114.98	40.48	77.11	103.47	18.74	16.29	96.15

Table 25: continued

Accession	k10	cobdia	cobc	rachis	pith	rachisseg	larea	plantear	GDDleafnum5
Ames 22643	15.72	20.49	1.06	12.29	6.92	3.85	429.58	3.18	110.28
Ames 26908	32.79	30.19	2.00	20.24	9.97	3.96	696.40	1.94	87.56
Ames 6048	36.54	22.59	1.00	13.58	6.30	4.84	520.50	1.96	94.90
Ames 19097	32.49	27.67	2.00	18.62	9.60	3.79	687.60	2.09	87.43
Zuni	26.48	26.86	1.07	16.88	9.59	4.50	747.26	2.66	98.35
NSL 2830	34.62	21.74	1.00	11.92	5.10	4.73	670.75	1.87	105.94
NSL 283388	13.60	20.08	1.56	11.26	4.73	4.01	636.43	1.71	113.73
NSL 67047	30.37	33.37	1.00	22.62	11.34	3.99	872.40	1.58	88.30
NSL 67048	28.99	34.24	1.00	22.10	12.29	3.83	857.73	1.62	91.26
NSL 67049	22.84	33.40	1.00	22.73	11.88	3.28	849.75	1.59	93.68
NSL 67051	25.87	31.23	1.00	20.46	11.06	3.88	743.15	1.41	96.47
NSL 67052	33.05	30.28	1.20	20.24	10.37	3.63	753.70	1.78	86.98
NSL 67053	30.19	27.33	1.50	18.03	10.40	4.58	748.20	2.18	92.68
NSL 67054	28.24	27.49	1.71	17.17	9.86	4.53	729.24	2.25	95.48
NSL 67055	35.87	31.03	1.80	20.03	10.63	3.86	640.25	2.00	85.23
NSL 67056	26.03	25.43	1.35	15.64	8.47	3.95	613.60	2.22	95.84
NSL 67057	31.68	26.33	1.49	17.22	9.88	4.23	635.07	2.40	106.01
NSL 67058	26.26	23.63	1.43	15.20	7.71	3.87	549.55	2.14	93.73
NSL 67059	28.54	24.95	1.45	16.10	8.58	3.75	577.28	2.25	90.36
NSL 67060	30.01	24.02	1.32	15.14	7.64	4.30	610.39	2.39	93.77
NSL 67061	26.16	24.91	1.25	15.19	7.97	4.04	568.10	2.27	92.21
NSL 67062	36.63	28.53	1.55	17.99	9.48	4.14	647.74	2.11	94.90
NSL 67063	34.61	28.14	1.41	17.33	9.19	4.25	707.19	2.01	89.30
NSL 67064	29.92	26.01	1.59	16.81	9.66	4.25	668.65	2.37	106.79
NSL 67065	26.06	25.04	1.52	15.88	8.99	4.44	739.49	2.28	95.51
NSL 67066	32.71	28.36	1.15	17.65	10.63	4.49	607.08	2.10	102.34
NSL 67068	29.91	33.84	1.00	20.75	11.83	3.76	713.78	1.57	88.24
NSL 68323	23.18	23.41	1.03	13.89	7.78	4.82	414.95	3.03	100.82
NSL 68324	26.50	23.35	1.02	14.89	8.36	4.73	410.03	3.00	101.26
NSL 68325	27.21	29.13	1.73	19.48	11.89	4.21	720.16	2.32	93.00
NSL 68326	26.92	24.39	1.77	15.72	9.45	4.66	663.21	2.72	106.26
NSL 68327	27.66	25.67	1.65	16.71	10.02	4.58	638.87	3.15	103.18
NSL 68329	32.24	27.28	1.30	17.46	8.63	4.49	679.41	1.78	90.31
NSL 68330	26.29	24.88	1.05	16.05	9.40	4.35	515.33	3.14	110.75
NSL 68331	26.21	25.02	1.04	15.71	9.57	4.73	579.26	2.62	104.36
NSL 68332	26.02	25.29	1.06	16.51	9.47	4.61	519.42	3.17	117.29
NSL 68334	29.10	24.34	1.08	15.47	8.94	4.75	474.96	3.54	113.59
NSL 68335	31.06	29.70	1.16	18.07	8.80	4.01	878.63	1.70	86.76
NSL 68336	31.26	33.72	1.00	22.57	11.71	3.80	780.08	1.54	92.16
PI 213697	30.52	29.72	2.00	18.85	9.99	4.14	627.15	2.12	93.84

Table 25: continued

Accession	k10	cobdia	cobc	rachis	pith	rachisseg	larea	plantear	GDDleafnum5
PI 213712	32.79	27.65	2.00	17.38	8.59	3.64	735.55	2.08	84.56
PI 213714	24.54	22.31	1.02	13.05	6.36	4.57	536.39	2.26	99.74
PI 213728	25.59	26.82	1.75	17.16	8.94	3.70	517.40	2.29	95.15
PI 213729	27.25	27.48	1.69	18.77	9.88	4.44	573.57	3.07	118.27
PI 213730	24.08	21.82	2.00	12.16	6.22	3.89	392.23	2.64	116.53
PI 213732	32.54	25.48	1.00	16.77	9.26	4.06	594.42	1.94	117.32
PI 213733	19.60	23.49	1.46	14.58	8.39	4.35	527.73	3.35	116.72
PI 213734	23.50	24.31	1.00	16.49	9.90	4.88	544.32	2.33	113.34
PI 213735	29.36	25.44	1.00	15.97	9.13	4.88	517.85	2.92	110.61
PI 213736	24.43	20.31	1.03	11.15	5.47	4.42	452.84	2.80	117.66
PI 213737	26.84	24.65	1.76	15.97	9.37	4.34	450.81	3.42	98.41
PI 213738	25.33	25.32	1.00	17.20	10.42	4.93	457.66	3.83	109.32
PI 213739	24.08	25.99	1.09	17.44	9.34	4.23	496.48	2.64	92.46
PI 213740	19.35	19.38	1.06	10.15	4.23	4.18	542.95	2.15	116.54
PI 213741	25.28	24.36	1.00	14.62	8.83	4.62	407.71	2.40	101.56
PI 213757	31.41	21.06	1.79	13.58	6.46	3.98	683.94	1.95	104.08
PI 213767	31.14	28.81	1.00	19.23	9.83	4.74	620.67	2.26	98.73
PI 217405	26.49	31.35	1.53	20.45	9.58	3.39	793.58	1.78	106.67
PI 217408	32.74	22.39	1.02	14.26	7.63	4.46	393.12	3.63	106.20
PI 217411	28.10	22.96	1.29	13.32	7.48	4.31	413.39	2.97	106.67
PI 218130	22.50	29.48	1.04	18.60	11.25	4.28	752.57	2.05	99.89
PI 218131	29.32	26.44	1.03	17.21	9.58	4.21	725.55	2.30	94.70
PI 218133	27.26	32.26	1.31	22.15	13.89	4.29	777.64	1.95	104.15
PI 218134	22.94	29.69	1.00	19.00	10.16	3.79	545.22	2.27	96.72
PI 218135	25.50	29.18	1.14	20.30	12.25	4.50	454.07	3.42	103.42
PI 218136	21.13	23.67	1.03	14.94	8.39	4.57	548.59	3.07	119.57
PI 218137	26.72	26.09	1.10	17.02	9.38	4.94	671.41	2.72	93.70
PI 218138	30.20	34.59	1.00	24.08	13.07	4.63	804.02	2.05	103.59
PI 218139	27.96	28.19	1.11	19.63	10.42	4.52	836.98	2.22	106.46
PI 218140	18.54	20.60	1.00	11.42	5.32	3.83	547.58	2.06	105.37
PI 218141	29.63	27.40	1.27	18.22	9.50	4.03	661.12	2.52	101.65
PI 218142	30.78	29.92	1.06	20.23	11.79	4.53	486.56	3.37	96.16
PI 218143	25.94	26.48	1.15	16.14	8.77	4.32	797.73	2.11	98.41
PI 218144	27.97	31.60	1.09	20.10	11.06	4.46	782.95	2.28	97.42
PI 218145	20.17	23.55	1.07	13.74	7.33	4.08	626.52	2.42	96.18
PI 218146	25.79	26.56	1.03	17.12	9.93	4.24	665.35	2.52	101.69
PI 218147	28.23	29.95	1.08	20.08	11.48	4.62	783.78	2.06	104.12
PI 218148	26.83	32.00	1.02	20.20	11.79	4.34	851.54	1.99	101.48
PI 218149	33.13	27.62	1.02	18.82	11.70	4.49	539.89	2.90	102.31
PI 218150	24.38	25.26	1.47	15.96	8.84	4.25	790.29	2.16	101.97
PI 218151	24.96	26.70	1.22	17.75	9.75	4.15	708.31	2.34	113.42

Table 25: continued

Accession	k10	cobdia	cobc	rachis	pith	rachisseg	larea	plantear	GDDleafnum5
PI 218152	29.90	28.61	1.34	19.67	10.49	4.54	512.59	3.02	92.18
PI 218153	21.73	23.64	1.02	13.47	7.21	4.16	723.34	2.15	103.91
PI 218154	31.50	30.28	1.96	19.26	10.27	3.92	814.70	2.07	89.09
PI 218155	29.63	28.86	1.71	17.84	9.16	4.63	891.27	2.13	94.78
PI 218156	23.02	26.42	1.22	17.10	10.17	4.16	756.36	2.16	101.75
PI 218157	25.01	26.49	1.13	17.91	10.60	4.43	745.37	2.33	95.80
PI 218158	27.43	25.97	1.13	16.86	9.39	4.73	876.72	2.12	104.75
PI 218159	27.20	28.60	1.49	18.49	9.98	4.78	852.11	2.17	107.05
PI 218160	26.38	26.73	1.02	17.46	10.80	4.61	517.99	3.30	108.53
PI 218161	27.73	26.92	1.04	17.19	10.56	5.12	515.67	3.42	106.44
PI 218162	25.50	27.14	1.00	17.92	10.60	4.31	601.03	3.07	108.33
PI 218163	23.56	23.83	1.06	16.33	9.76	4.17	540.02	2.69	115.28
PI 218164	25.56	25.39	1.02	15.79	9.15	4.39	605.95	3.05	109.29
PI 218165	26.57	24.06	1.15	14.35	8.28	4.47	559.96	2.80	119.05
PI 218166	25.20	23.20	1.18	13.86	7.86	4.39	555.06	2.98	110.70
PI 218167	36.31	32.18	1.55	21.09	10.89	4.93	778.12	2.41	106.07
PI 218168	25.89	25.86	1.40	16.87	9.91	4.63	656.70	2.33	108.18
PI 218169	29.50	29.13	1.08	19.28	11.64	4.53	790.11	2.32	104.31
PI 218170	24.55	25.13	1.26	15.33	9.34	4.42	724.08	2.41	105.94
PI 218171	34.19	33.11	1.48	21.59	11.07	4.04	760.62	1.96	98.05
PI 218172	34.99	33.99	1.43	23.30	13.07	4.42	726.13	2.10	96.72
PI 218173	29.76	29.79	1.22	17.74	9.07	5.19	827.18	2.05	99.76
PI 218174	21.03	22.20	1.02	14.18	8.52	4.06	372.61	4.67	107.72
PI 218175	27.06	25.14	1.03	16.06	9.35	4.29	686.85	2.40	113.55
PI 218176	33.51	28.15	1.61	17.79	10.60	4.82	742.95	2.45	108.41
PI 218178	32.84	30.79	1.66	19.71	11.57	4.39	654.70	2.58	109.64
PI 218179	22.41	22.49	1.09	12.54	6.66	4.33	560.21	2.47	104.34
PI 218180	28.93	33.14	1.00	22.41	12.31	3.91	720.37	1.65	98.32
PI 218181	31.18	29.51	1.00	19.47	10.40	3.85	794.87	1.66	94.66
PI 218182	26.92	33.23	1.00	21.13	12.11	4.00	786.74	1.53	96.89
PI 218183	24.64	33.73	1.00	21.61	11.87	3.68	783.59	1.79	105.46
PI 218184	29.50	33.56	1.00	21.76	12.41	4.09	772.85	1.62	91.77
PI 218185	23.08	20.61	1.06	11.69	5.57	4.33	555.48	2.29	98.43
PI 218186	25.04	20.16	1.00	11.94	6.27	4.71	434.84	3.05	96.52
PI 218187	27.33	22.37	1.04	13.08	7.03	4.65	514.82	2.54	103.25
PI 218188	25.71	26.46	1.37	16.30	9.06	4.29	698.82	2.07	94.61
PI 218189	24.20	30.53	1.23	20.02	10.55	3.26	723.71	1.59	87.42
PI 218190	27.31	31.13	1.23	20.09	10.38	3.76	768.72	1.58	90.53
PI 218191	28.24	33.19	1.00	21.36	11.57	3.97	862.60	1.61	92.93
PI 222285	24.30	23.95	1.00	16.30	9.64	4.72	217.71	5.57	118.13
PI 311229	22.84	27.29	1.12	18.06	10.90	4.29	625.50	2.62	109.11

Table 25: continued

Accession	k10	cobdia	cobc	rachis	pith	rachisseg	larea	plantear	GDDleafnum5
PI 311243	30.38	26.39	1.00	16.62	7.88	3.67	682.89	1.72	86.34
PI 317674	28.39	26.73	1.06	18.07	10.40	4.78	666.75	2.81	101.89
PI 317675	24.61	23.46	1.00	15.09	8.80	4.49	537.44	2.83	109.42
PI 317678	24.34	25.56	1.07	16.23	9.34	4.74	543.76	2.69	104.35
PI 317679	28.28	25.61	1.06	16.79	9.31	4.76	623.08	2.71	111.98
PI 408705	24.06	29.08	2.00	18.69	10.74	3.62	635.90	2.07	91.84
PI 420245	16.00	19.00	1.33	10.23	4.28	3.67	544.83	1.74	107.08
PI 420247	17.33	21.51	1.13	13.50	8.03	3.62	478.08	3.27	114.13
PI 420248	27.63	26.44	1.04	17.34	9.19	4.53	469.75	2.88	121.02
PI 420250	22.81	26.09	1.08	16.39	9.19	4.93	675.99	2.64	121.75
PI 420251	23.04	21.02	1.00	12.05	6.14	4.25	390.72	3.46	105.26
PI 420252	20.24	29.02	1.00	16.98	9.09	4.04	729.01	1.63	102.74
PI 451716	20.29	21.39	1.00	12.13	6.88	4.22	475.13	2.50	102.45
PI 474206	24.67	24.66	1.00	15.39	7.62	4.69	659.44	1.68	114.18
PI 474209	21.38	24.15	1.00	13.86	7.16	4.70	680.51	1.89	120.25
PI 476868	27.68	25.85	1.23	16.28	9.24	4.93	511.66	3.16	102.19
PI 476869	22.41	22.70	1.19	14.64	8.36	4.25	512.80	2.88	114.91
PI 476870	34.11	29.57	1.84	20.16	12.67	5.16	640.38	2.88	114.08
PI 484413	25.96	20.90	1.03	11.10	5.19	4.36	443.28	2.63	109.66
PI 484433	32.63	23.38	1.70	13.77	6.09	4.69	563.77	2.14	116.61
PI 484482	35.01	22.98	1.21	12.54	4.91	4.64	527.69	1.83	106.88
PI 485116	30.97	24.12	1.00	14.36	6.35	4.66	435.03	2.34	113.14
PI 490921	12.88	19.03	1.35	10.27	5.02	3.46	605.95	1.58	124.95
PI 490973	18.90	24.18	1.00	14.21	7.32	4.30	617.62	1.85	114.91
PI 503562	26.70	22.86	1.04	14.75	8.96	4.66	578.83	2.74	118.94
PI 503563	22.49	21.83	1.00	12.27	6.33	4.20	537.45	2.60	96.50
PI 503564	25.33	25.49	1.00	17.18	10.48	4.61	576.25	2.62	112.74
PI 503565	27.33	24.88	1.03	16.15	9.73	4.32	652.81	2.86	112.67
PI 503566	22.50	23.97	1.13	14.68	8.89	4.29	677.73	2.63	115.71
PI 503567	31.88	25.08	1.06	16.67	9.83	4.71	553.88	2.89	116.27
PI 503568	28.26	25.15	1.29	15.29	8.63	4.85	617.75	2.83	113.74
PI 503573	22.31	21.76	1.00	12.12	6.01	4.43	441.13	2.64	106.72
PI 508270	24.33	30.08	1.12	17.70	9.49	3.45	726.62	1.63	94.97
PI 550563	25.28	28.53	1.20	17.06	9.02	3.47	743.61	1.78	94.48
PI 629147	19.95	27.40	1.12	17.13	9.01	3.83	650.81	1.55	98.59

Table 25: continued

Accession	branchtass	spiketass	dialength	cobeardia	kwidth length	kthick length	kthick width
Ames 22643	0.28	0.61	0.23	0.60	0.80	0.41	0.51
Ames 26908	0.31	0.56	0.22	0.60	0.63	0.32	0.51
Ames 6048	0.41	0.54	0.23	0.64	1.07	0.53	0.49
Ames 19097	0.24	0.57	0.22	0.57	0.62	0.28	0.46
Zuni	0.33	0.59	0.17	0.65	0.79	0.45	0.58
NSL 2830	0.39	0.54	0.13	0.65	1.17	0.51	0.43
NSL 283388	0.32	0.55	0.18	0.75	0.97	0.55	0.57
NSL 67047	0.37	0.58	0.27	0.66	0.80	0.36	0.45
NSL 67048	0.37	0.55	0.28	0.65	0.74	0.32	0.43
NSL 67049	0.36	0.54	0.31	0.64	0.70	0.29	0.40
NSL 67051	0.39	0.54	0.25	0.64	0.73	0.31	0.43
NSL 67052	0.37	0.58	0.27	0.59	0.70	0.28	0.41
NSL 67053	0.36	0.52	0.18	0.64	0.77	0.42	0.54
NSL 67054	0.33	0.58	0.17	0.67	0.82	0.45	0.56
NSL 67055	0.34	0.53	0.24	0.64	0.79	0.35	0.45
NSL 67056	0.29	0.59	0.19	0.63	0.80	0.38	0.48
NSL 67057	0.28	0.61	0.21	0.64	0.91	0.46	0.51
NSL 67058	0.31	0.59	0.23	0.60	0.82	0.42	0.51
NSL 67059	0.30	0.60	0.22	0.61	0.82	0.40	0.49
NSL 67060	0.33	0.57	0.18	0.62	0.88	0.41	0.47
NSL 67061	0.31	0.57	0.19	0.65	0.85	0.44	0.53
NSL 67062	0.31	0.59	0.21	0.63	0.89	0.39	0.45
NSL 67063	0.32	0.59	0.21	0.61	0.85	0.38	0.45
NSL 67064	0.27	0.63	0.22	0.63	0.88	0.44	0.51
NSL 67065	0.32	0.55	0.17	0.64	0.83	0.50	0.60
NSL 67066	0.32	0.63	0.23	0.64	0.87	0.45	0.51
NSL 67068	0.41	0.50	0.25	0.64	0.70	0.31	0.45
NSL 68323	0.24	0.67	0.18	0.68	0.94	0.57	0.62
NSL 68324	0.20	0.68	0.20	0.63	0.87	0.50	0.58
NSL 68325	0.35	0.52	0.18	0.67	0.84	0.42	0.50
NSL 68326	0.26	0.62	0.19	0.60	0.78	0.41	0.53
NSL 68327	0.27	0.58	0.19	0.64	0.83	0.45	0.54
NSL 68329	0.33	0.61	0.19	0.64	0.91	0.41	0.45
NSL 68330	0.26	0.70	0.21	0.62	0.80	0.43	0.54
NSL 68331	0.32	0.59	0.19	0.65	0.87	0.48	0.56
NSL 68332	0.27	0.70	0.25	0.64	0.89	0.50	0.57
NSL 68334	0.29	0.68	0.21	0.63	0.90	0.49	0.55
NSL 68335	0.34	0.63	0.24	0.61	0.72	0.34	0.48
NSL 68336	0.39	0.55	0.27	0.68	0.86	0.33	0.38
PI 213697	0.30	0.58	0.21	0.65	0.77	0.37	0.49
PI 213712	0.38	0.53	0.23	0.57	0.65	0.31	0.47

Table 25: continued

Accession	branchtass	spiketass	dialength	cobeardia	kwidth length	kthick length	kthick width
PI 213714	0.28	0.57	0.19	0.66	0.95	0.54	0.57
PI 213728	0.31	0.65	0.24	0.61	0.71	0.34	0.49
PI 213729	0.32	0.50	0.20	0.70	0.96	0.51	0.55
PI 213730	0.33	0.57	0.22	0.63	0.96	0.46	0.49
PI 213732	0.40	0.54	0.25	0.64	1.04	0.45	0.42
PI 213733	0.29	0.65	0.18	0.68	0.81	0.52	0.65
PI 213734	0.28	0.66	0.23	0.65	0.86	0.56	0.65
PI 213735	0.35	0.60	0.20	0.67	0.94	0.52	0.57
PI 213736	0.25	0.62	0.21	0.65	1.05	0.56	0.54
PI 213737	0.26	0.62	0.21	0.66	0.94	0.45	0.48
PI 213738	0.36	0.57	0.17	0.68	0.87	0.52	0.60
PI 213739	0.33	0.53	0.22	0.65	0.86	0.44	0.52
PI 213740	0.43	0.41	0.16	0.68	1.11	0.55	0.50
PI 213741	0.18	0.73	0.21	0.72	1.01	0.65	0.65
PI 213757	0.31	0.60	0.18	0.60	1.09	0.44	0.40
PI 213767	0.32	0.59	0.22	0.70	1.02	0.54	0.52
PI 217405	0.36	0.59	0.35	0.57	0.61	0.27	0.44
PI 217408	0.28	0.51	0.18	0.65	1.20	0.51	0.43
PI 217411	0.29	0.65	0.25	0.72	1.13	0.52	0.47
PI 218130	0.30	0.64	0.21	0.67	0.77	0.42	0.54
PI 218131	0.32	0.58	0.19	0.63	0.84	0.40	0.48
PI 218133	0.37	0.56	0.22	0.67	0.77	0.42	0.54
PI 218134	0.35	0.56	0.25	0.68	0.86	0.38	0.44
PI 218135	0.31	0.57	0.23	0.67	0.93	0.49	0.53
PI 218136	0.30	0.59	0.21	0.67	0.87	0.51	0.60
PI 218137	0.29	0.61	0.18	0.65	0.84	0.47	0.56
PI 218138	0.34	0.63	0.23	0.69	0.91	0.44	0.49
PI 218139	0.36	0.57	0.17	0.64	0.82	0.44	0.54
PI 218140	0.27	0.59	0.18	0.60	0.66	0.42	0.63
PI 218141	0.32	0.52	0.21	0.65	0.85	0.42	0.49
PI 218142	0.31	0.60	0.20	0.72	0.98	0.52	0.53
PI 218143	0.33	0.57	0.17	0.66	0.76	0.44	0.58
PI 218144	0.31	0.63	0.22	0.68	0.78	0.44	0.57
PI 218145	0.35	0.56	0.15	0.65	0.76	0.45	0.59
PI 218146	0.31	0.59	0.20	0.65	0.86	0.46	0.54
PI 218147	0.34	0.60	0.19	0.68	0.81	0.42	0.53
PI 218148	0.33	0.57	0.19	0.69	0.80	0.43	0.54
PI 218149	0.32	0.60	0.20	0.66	0.93	0.47	0.51
PI 218150	0.34	0.58	0.18	0.62	0.80	0.40	0.52
PI 218151	0.30	0.60	0.19	0.64	0.82	0.44	0.55
PI 218152	0.32	0.58	0.20	0.66	0.95	0.47	0.49
PI 218153	0.35	0.57	0.15	0.67	0.85	0.47	0.55

Table 25: continued

Accession	branchtass	spiketass	dialength	cobeardia	kwidth length	kthick length	kthick width
PI 218154	0.34	0.56	0.19	0.64	0.74	0.36	0.50
PI 218155	0.35	0.58	0.18	0.68	0.81	0.45	0.55
PI 218156	0.33	0.55	0.17	0.65	0.80	0.43	0.54
PI 218157	0.33	0.55	0.20	0.62	0.77	0.42	0.55
PI 218158	0.36	0.59	0.15	0.63	0.88	0.49	0.57
PI 218159	0.36	0.55	0.16	0.67	0.83	0.45	0.55
PI 218160	0.33	0.61	0.20	0.66	0.84	0.48	0.57
PI 218161	0.31	0.62	0.20	0.69	0.87	0.51	0.60
PI 218162	0.28	0.67	0.21	0.67	0.87	0.46	0.53
PI 218163	0.27	0.67	0.20	0.63	0.82	0.43	0.52
PI 218164	0.28	0.63	0.20	0.65	0.82	0.47	0.57
PI 218165	0.29	0.65	0.19	0.64	0.84	0.47	0.55
PI 218166	0.28	0.63	0.17	0.62	0.81	0.44	0.55
PI 218167	0.32	0.60	0.18	0.70	0.89	0.46	0.52
PI 218168	0.33	0.53	0.19	0.64	0.80	0.49	0.61
PI 218169	0.30	0.62	0.16	0.66	0.83	0.44	0.52
PI 218170	0.28	0.66	0.17	0.64	0.80	0.47	0.59
PI 218171	0.33	0.60	0.21	0.67	0.86	0.39	0.46
PI 218172	0.31	0.62	0.21	0.67	0.81	0.41	0.50
PI 218173	0.36	0.62	0.16	0.69	0.84	0.48	0.57
PI 218174	0.24	0.68	0.25	0.61	0.83	0.39	0.47
PI 218175	0.30	0.64	0.20	0.62	0.82	0.45	0.55
PI 218176	0.28	0.68	0.20	0.66	0.92	0.47	0.51
PI 218178	0.28	0.68	0.24	0.66	0.84	0.42	0.50
PI 218179	0.26	0.64	0.18	0.63	0.87	0.48	0.56
PI 218180	0.35	0.60	0.27	0.67	0.74	0.34	0.46
PI 218181	0.34	0.58	0.25	0.62	0.81	0.36	0.45
PI 218182	0.40	0.56	0.26	0.68	0.82	0.37	0.44
PI 218183	0.31	0.63	0.25	0.68	0.73	0.33	0.46
PI 218184	0.37	0.57	0.25	0.67	0.78	0.35	0.45
PI 218185	0.24	0.65	0.19	0.60	0.88	0.47	0.53
PI 218186	0.23	0.69	0.18	0.63	0.99	0.55	0.56
PI 218187	0.21	0.73	0.17	0.64	0.97	0.49	0.51
PI 218188	0.33	0.57	0.16	0.68	0.85	0.47	0.55
PI 218189	0.39	0.57	0.32	0.61	0.65	0.27	0.41
PI 218190	0.39	0.56	0.26	0.65	0.75	0.32	0.43
PI 218191	0.37	0.57	0.27	0.66	0.78	0.32	0.42
PI 222285	0.25	0.72	0.25	0.70	1.02	0.57	0.56
PI 311229	0.37	0.59	0.23	0.66	0.83	0.46	0.55
PI 311243	0.39	0.55	0.25	0.57	0.65	0.27	0.42
PI 317674	0.32	0.61	0.21	0.66	0.91	0.47	0.53
PI 317675	0.28	0.64	0.20	0.63	0.90	0.46	0.52

Table 25: continued

Accession	branchtass	spiketass	dialength	cobeardia	kwidth length	kthick length	kthick width
PI 317678	0.29	0.62	0.18	0.67	0.96	0.50	0.52
PI 317679	0.34	0.61	0.18	0.65	0.89	0.46	0.52
PI 408705	0.30	0.61	0.26	0.60	0.57	0.30	0.52
PI 420245	0.35	0.49	0.21	0.64	0.87	0.45	0.53
PI 420247	0.30	0.59	0.24	0.61	0.81	0.38	0.49
PI 420248	0.33	0.61	0.23	0.67	0.90	0.54	0.60
PI 420250	0.29	0.67	0.18	0.68	0.93	0.55	0.59
PI 420251	0.21	0.68	0.21	0.63	0.87	0.48	0.55
PI 420252	0.29	0.67	0.23	0.71	0.80	0.42	0.53
PI 451716	0.22	0.73	0.21	0.61	0.81	0.45	0.56
PI 474206	0.36	0.57	0.19	0.68	1.03	0.50	0.48
PI 474209	0.28	0.61	0.16	0.71	0.95	0.57	0.62
PI 476868	0.30	0.60	0.17	0.67	0.95	0.54	0.57
PI 476869	0.30	0.63	0.21	0.61	0.82	0.46	0.56
PI 476870	0.26	0.70	0.22	0.68	0.94	0.47	0.52
PI 484413	0.15	0.66	0.19	0.64	0.85	0.48	0.56
PI 484433	0.23	0.67	0.21	0.59	0.81	0.44	0.55
PI 484482	0.23	0.71	0.18	0.61	0.86	0.44	0.53
PI 485116	0.15	0.70	0.21	0.64	0.84	0.48	0.58
PI 490921	0.27	0.70	0.17	0.69	0.80	0.50	0.63
PI 490973	0.34	0.59	0.18	0.71	0.95	0.52	0.56
PI 503562	0.32	0.60	0.18	0.64	0.85	0.51	0.61
PI 503563	0.26	0.65	0.17	0.65	0.84	0.49	0.58
PI 503564	0.33	0.61	0.20	0.63	0.83	0.47	0.57
PI 503565	0.30	0.65	0.18	0.63	0.86	0.46	0.53
PI 503566	0.30	0.64	0.18	0.65	0.81	0.48	0.60
PI 503567	0.28	0.66	0.22	0.63	0.92	0.45	0.50
PI 503568	0.32	0.61	0.18	0.66	0.84	0.49	0.59
PI 503573	0.27	0.64	0.17	0.66	0.92	0.54	0.58
PI 508270	0.33	0.58	0.24	0.66	0.71	0.33	0.47
PI 550563	0.34	0.59	0.22	0.66	0.74	0.34	0.46
PI 629147	0.39	0.58	0.24	0.67	0.76	0.39	0.53

Table 26: Accession mean, minimum and maximum for plant height in the three environments

Accession number	Ethnic group	Language group	Environment	Plant height (cm)		
				Average	Minimum	Maximum
PI 218140	Acoma Pueblo	Keresan	IA 04	217.27	155	300
			NM 04	137.65	105	180
			NM 05	153.47	106	195
PI 218141	Acoma Pueblo	Keresan	IA 04	240.36	135	300
			NM 04	183.04	148	216
			NM 05	165.28	115	205
PI 218167	Acoma Pueblo	Keresan	IA 04	223.75	180	285
			NM 04	178.89	133	202
			NM 05	166.20	123	219
PI 218168	Acoma Pueblo	Keresan	IA 04	205.89	115	270
			NM 04	170.55	125	201
			NM 05	168.00	93	205
PI 218131	Cochiti Pueblo	Keresan	IA 04	242.82	190	300
			NM 04	189.53	155	224
			NM 05	178.15	139	204
PI 218145	Cochiti Pueblo	Keresan	IA 04	219.46	170	295
			NM 04	168.89	127	203
			NM 05	162.35	98	225
PI 218150	Cochiti Pueblo	Keresan	IA 04	225.59	130	310
			NM 04	162.61	132	204
			NM 05	175.20	100	208
PI 218151	Cochiti Pueblo	Keresan	IA 04	211.40	130	280
			NM 04	173.39	132	202
			NM 05	178.00	134	209
PI 218133	Laguna Pueblo	Keresan	IA 04	225.14	140	296
			NM 04	188.14	134	239
			NM 05	202.95	162	258
PI 218146	Laguna Pueblo	Keresan	IA 04	210.46	125	273
			NM 04	158.93	97	192
			NM 05	167.75	100	244
PI 218147	Laguna Pueblo	Keresan	IA 04	240.27	175	315
			NM 04	195.30	114	241
			NM 05	197.85	143	234
PI 218169	Laguna Pueblo	Keresan	IA 04	215.28	135	313
			NM 04	170.56	90	225
			NM 05	162.65	123	202
PI 218170	Laguna Pueblo	Keresan	IA 04	218.33	188	257
			NM 04	169.06	138	255
			NM 05	175.65	94	261
PI 218153	San Felipe Pueblo	Keresan	IA 04	227.86	135	310
			NM 04	183.55	124	228
			NM 05	190.40	141	220
PI 218154	San Felipe Pueblo	Keresan	IA 04	274.32	190	315
			NM 04	199.28	169	227
			NM 05	202.90	106	238

Table 26: continued

Accession number	Ethnic group	Language group	Environment	Plant height (cm)		
				Average	Minimum	Maximum
PI 218130	Santo Domingo Pueblo	Keresan	IA 04	234.00	170	310
			NM 04	195.11	145	250
			NM 05	218.79	159	305
PI 218143	Santo Domingo Pueblo	Keresan	IA 04	244.27	160	295
			NM 04	176.41	137	204
			NM 05	190.45	148	226
PI 218155	Santo Domingo Pueblo	Keresan	IA 04	244.32	180	320
			NM 04	194.22	137	255
			NM 05	195.63	171	244
PI 218156	Santo Domingo Pueblo	Keresan	IA 04	244.91	125	310
			NM 04	216.94	192	244
			NM 05	214.40	160	249
PI 218139	Zia Pueblo	Keresan	IA 04	247.57	169	296
			NM 04	195.94	144	257
			NM 05	220.30	153	288
PI 218158	Zia Pueblo	Keresan	IA 04	275.21	195	350
			NM 04	221.39	167	271
			NM 05	212.40	136	308
PI 218159	Zia Pueblo	Keresan	IA 04	234.22	165	315
			NM 04	216.28	116	254
			NM 05	193.00	148	230
PI 218188	Zia Pueblo	Keresan	IA 04	249.83	185	308
			NM 04	168.78	133	203
			NM 05	211.10	158	248
PI 218138	Isleta Pueblo	Tanoan	IA 04	226.32	110	310
			NM 04	203.11	164	268
			NM 05	215.55	146	285
PI 218144	Isleta Pueblo	Tanoan	IA 04	258.32	176	307
			NM 04	191.67	162	247
			NM 05	206.60	145	247
PI 218148	Isleta Pueblo	Tanoan	IA 04	248.77	200	315
			NM 04	183.89	102	226
			NM 05	217.80	157	267
PI 218171	Jemez Pueblo	Tanoan	IA 04	264.33	217	326
			NM 04	207.56	182	241
			NM 05	186.50	123	245
PI 218172	Jemez Pueblo	Tanoan	IA 04	258.59	200	320
			NM 04	204.28	170	242
			NM 05	214.10	149	301
PI 218173	Jemez Pueblo	Tanoan	IA 04	243.72	145	315
			NM 04	204.17	155	242
			NM 05	217.80	155	272
PI 218135	Picuris Pueblo	Tanoan	IA 04	164.09	120	211
			NM 04	129.93	97	166
			NM 05	120.45	80	160

Table 26: continued

Accession number	Ethnic group	Language group	Environment	Plant height (cm)		
				Average	Minimum	Maximum
PI 218142	Picuris Pueblo	Tanoan	IA 04	179.50	120	225
			NM 04	119.27	72	160
			NM 05	121.28	78	165
PI 218157	Santa Clara Pueblo	Tanoan	IA 04	243.67	175	320
			NM 04	174.96	131	202
			NM 05	185.60	143	246
PI 218149	Taos Pueblo	Tanoan	IA 04	180.09	90	267
			NM 04	134.00	81	162
			NM 05	134.35	60	174
PI 218152	Taos Pueblo	Tanoan	IA 04	164.25	120	206
			NM 04	131.43	83	183
			NM 05	152.30	80	192
PI 476868	Taos Pueblo	Tanoan	IA 04	163.72	82	231
			NM 04	149.32	117	186
			NM 05	132.00	71	178
PI 218134	Tesuque Pueblo	Tanoan	IA 04	208.50	135	272
			NM 04	150.97	113	195
			NM 05	145.33	100	206
PI 218136	Tesuque Pueblo	Tanoan	IA 04	131.52	70	184
			NM 04	97.06	70.	139
			NM 05	104.05	69	142
PI 218137	Tesuque Pueblo	Tanoan	IA 04	227.23	164	300
			NM 04	157.59	131	208
			NM 05	170.50	126	210
Zuni	Zuni	Zuni	IA 04	221.33	160	295
			NM 04	191.21	148	242
			NM 05	178.00	114	244
Ames 22643	Hopi	Hopi	IA 04	113.65	75	165
			NM 04	78.93	36	105
			NM 05	82.78	44	125
NSL 67047	Hopi	Hopi	IA 04	323.28	246	380
			NM 04	231.13	172	276
			NM 05	246.90	172	304
NSL 67048	Hopi	Hopi	IA 04	291.50	235	375
			NM 04	251.91	204	301
			NM 05	246.85	207	289
NSL 67049	Hopi	Hopi	IA 04	353.50	285	430
			NM 04	245.44	204	306
			NM 05	285.95	233	339
NSL 67051	Hopi	Hopi	IA 04	317.72	275	384
			NM 04	259.57	210	328
			NM 05	272.47	219	322
NSL 67052	Hopi	Hopi	IA 04	263.00	200	334
			NM 04	166.08	114	209
			NM 05	202.95	134	270

Table 26: continued

Accession number	Ethnic group	Language group	Environment	Plant height (cm)		
				Average	Minimum	Maximum
NSL 67053	Hopi	Hopi	IA 04	248.39	200	315
			NM 04	184.41	156	224
			NM 05	202.75	148	228
NSL 67054	Hopi	Hopi	IA 04	250.39	193	315
			NM 04	177.67	131	233
			NM 05	202.00	156	236
NSL 67055	Hopi	Hopi	IA 04	245.56	190	295
			NM 04	159.53	102	206
			NM 05	180.45	148	225
NSL 67056	Hopi	Hopi	IA 04	205.44	165	285
			NM 04	157.83	119	202
			NM 05	148.75	92	198
NSL 67057	Hopi	Hopi	IA 04	204.83	130	279
			NM 04	139.82	107	182
			NM 05	161.45	129	201
NSL 67058	Hopi	Hopi	IA 04	205.11	165	271
			NM 04	151.92	109	208
			NM 05	131.75	65	193
NSL 67059	Hopi	Hopi	IA 04	222.33	134	282
			NM 04	155.89	115	211
			NM 05	136.65	93	170
NSL 67060	Hopi	Hopi	IA 04	212.39	121	298
			NM 04	155.15	122	189
			NM 05	151.85	123	188
NSL 67061	Hopi	Hopi	IA 04	233.89	170	320
			NM 04	157.93	120	182
			NM 05	148.80	105	194
NSL 67062	Hopi	Hopi	IA 04	258.33	190	340
			NM 04	193.34	164	228
			NM 05	190.35	125	229
NSL 67063	Hopi	Hopi	IA 04	270.33	214	326
			NM 04	201.22	159	230
			NM 05	195.95	115	307
NSL 67064	Hopi	Hopi	IA 04	187.56	140	266
			NM 04	150.91	122	193
			NM 05	144.05	83	187
NSL 67065	Hopi	Hopi	IA 04	241.78	150	307
			NM 04	163.00	132	196
			NM 05	175.00	143	204
NSL 67066	Hopi	Hopi	IA 04	169.44	120	232
			NM 04	135.91	98	164
			NM 05	157.40	83	212
NSL 67068	Hopi	Hopi	IA 04	329.17	270	363
			NM 04	251.91	198	288
			NM 05	241.45	191	266

Table 26: continued

Accession number	Ethnic group	Language group	Environment	Plant height (cm)		
				Average	Minimum	Maximum
NSL 68323	Hopi	Hopi	IA 04	157.17	94	220
			NM 04	121.68	93	178
			NM 05	109.70	71	144
NSL 68324	Hopi	Hopi	IA 04	184.00	120	240
			NM 04	107.48	76	141
			NM 05	122.10	97	170
NSL 68325	Hopi	Hopi	IA 04	250.00	120	312
			NM 04	201.39	163	234
			NM 05	170.45	121	211
NSL 68326	Hopi	Hopi	IA 04	194.11	115	238
			NM 04	183.18	124	239
			NM 05	166.40	121	223
NSL 68327	Hopi	Hopi	IA 04	193.83	110	262
			NM 04	158.56	126	249
			NM 05	171.60	121	229
NSL 68329	Hopi	Hopi	IA 04	263.06	205	290
			NM 04	197.78	163	250
			NM 05	191.25	153	255
NSL 68330	Hopi	Hopi	IA 04	159.72	110	210
			NM 04	115.33	69	166
			NM 05	122.60	77	162
NSL 68331	Hopi	Hopi	IA 04	165.89	115	213
			NM 04	128.39	93	158
			NM 05	142.45	101	217
NSL 68332	Hopi	Hopi	IA 04	134.21	80	195
			NM 04	110.90	73	179
			NM 05	116.63	76	140
NSL 68334	Hopi	Hopi	IA 04	136.33	75	190
			NM 04	108.23	70	168
			NM 05	109.75	65	153
NSL 68335	Hopi	Hopi	IA 04	270.39	190	362
			NM 04	212.05	173	238
			NM 05	244.95	209	291
NSL 68336	Hopi	Hopi	IA 04	289.75	230	343
			NM 04	208.95	169	286
			NM 05	227.42	175	280
PI 213733	Hopi	Hopi	IA 04	133.11	100	176
			NM 04	98.28	58	147
			NM 05	113.80	83	143
PI 213734	Hopi	Hopi	IA 04	120.44	80	173
			NM 04	89.54	58	117
			NM 05	101.40	70	147
PI 213735	Hopi	Hopi	IA 04	146.61	105	207
			NM 04	99.04	81	126
			NM 05	114.74	89	150

Table 26: continued

Accession number	Ethnic group	Language group	Environment	Plant height (cm)		
				Average	Minimum	Maximum
PI 218174	Hopi	Hopi	IA 04	126.78	85	167
			NM 04	76.97	56	108
			NM 05	82.85	48	106
PI 218175	Hopi	Hopi	IA 04	161.44	100	217
			NM 04	152.80	116	180
			NM 05	151.33	100	189
PI 218176	Hopi	Hopi	IA 04	180.06	85	250
			NM 04	139.17	89	191
			NM 05	150.55	86	206
PI 218178	Hopi	Hopi	IA 04	165.33	110	225
			NM 04	133.61	109	169
			NM 05	135.21	85	178
PI 420247	Hopi	Hopi	IA 04	124.72	90	160
			NM 04	91.85	62	122
			NM 05	107.90	53	146
PI 420248	Hopi	Hopi	IA 04	124.72	80	181
			NM 04	113.18	77	154
			NM 05	117.24	68	152
PI 420250	Hopi	Hopi	IA 04	140.33	65	192
			NM 04	124.83	111	168
			NM 05	125.90	93	176
PI 476869	Hopi	Hopi	IA 04	147.44	100	195
			NM 04	107.21	76	139
			NM 05	109.21	70	135
PI 503562	Hopi	Hopi	IA 04	144.61	95	203
			NM 04	117.34	81	173
			NM 05	124.65	75	158
PI 503564	Hopi	Hopi	IA 04	157.61	115	214
			NM 04	116.32	83	145
			NM 05	127.60	82	171
PI 503565	Hopi	Hopi	IA 04	162.78	95	206
			NM 04	113.41	77	143
			NM 05	150.85	111	209
PI 503566	Hopi	Hopi	IA 04	156.13	100	223
			NM 04	118.64	94	155
			NM 05	136.20	101	153
PI 503567	Hopi	Hopi	IA 04	161.44	75	208
			NM 04	123.10	95	154
			NM 05	121.00	84	144
PI 503563	Pima-Maricopa	Piman	IA 04	218.94	140	271
			NM 04	133.67	100	172
			NM 05	175.65	119	228
PI 420251	Pima-Maricopa	Piman	IA 04	178.56	100	218
			NM 04	124.13	87	157
			NM 05	124.40	85	166

Table 26: continued

Accession number	Ethnic group	Language group	Environment	Plant height (cm)		
				Average	Minimum	Maximum
PI 213714	Tohono O'odham	Piman	IA 04	226.83	160	307
			NM 04	154.36	109	188
			NM 05	182.00	138	215
PI 218179	Tohono O'odham	Piman	IA 04	237.22	202	277
			NM 04	138.50	103	174
			NM 05	168.35	128	217
PI 218180	Tohono O'odham	Piman	IA 04	268.33	230	325
			NM 04	217.00	174	252
			NM 05	211.15	144	254
PI 218181	Tohono O'odham	Piman	IA 04	272.94	235	343
			NM 04	219.05	173	268
			NM 05	232.67	176	269
PI 218182	Tohono O'odham	Piman	IA 04	295.71	250	355
			NM 04	222.66	177	275
			NM 05	251.20	184	296
PI 218183	Tohono O'odham	Piman	IA 04	292.89	210	410
			NM 04	237.86	191	273
			NM 05	230.60	158	291
PI 218184	Tohono O'odham	Piman	IA 04	320.67	270	395
			NM 04	224.40	187	259
			NM 05	247.15	184	282
PI 218185	Tohono O'odham	Piman	IA 04	218.72	183	267
			NM 04	141.00	120	190
			NM 05	155.75	120	192
PI 218189	Tohono O'odham	Piman	IA 04	257.28	200	348
			NM 04	200.89	159	260
			NM 05	211.35	162	253
PI 218190	Tohono O'odham	Piman	IA 04	299.78	250	338
			NM 04	198.15	162	255
			NM 05	233.00	179	287
PI 218191	Tohono O'odham	Piman	IA 04	322.83	280	390
			NM 04	233.85	177	268
			NM 05	246.88	192	316
PI 451716	Tohono O'odham	Piman	IA 04	162.67	105	220
			NM 04	116.12	92	141
			NM 05	123.00	99	150
PI 503573	Tohono O'odham	Piman	IA 04	213.00	163	278
			NM 04	107.20	66	134
			NM 05	127.90	95	170
PI 218186	Mojave	River Yuman	IA 04	175.88	120	232
			NM 04	132.23	73	182
			NM 05	118.45	77	147
PI 218187	Mojave	River Yuman	IA 04	179.56	120	262
			NM 04	125.57	95	166
			NM 05	137.85	101	194

Table 26: continued

Accession number	Ethnic group	Language group	Environment	Plant height (cm)		
				Average	Minimum	Maximum
PI 317674	Havasupai	Upland Yuman	IA 04	177.83	125	238
			NM 04	131.14	86	181
			NM 05	151.50	89	186
PI 317675	Havasupai	Upland Yuman	IA 04	128.00	87	192
			NM 04	110.18	86	140
			NM 05	113.55	67	144
PI 317678	Havasupai	Upland Yuman	IA 04	151.28	105	205
			NM 04	115.58	83	145
			NM 05	137.80	103	199
PI 317679	Havasupai	Upland Yuman	IA 04	163.53	135	192
			NM 04	122.00	103	148
			NM 05	135.00	91	180
PI 476870	Havasupai	Upland Yuman	IA 04	147.83	75	200
			NM 04	117.64	82	148
			NM 05	138.00	115	159
PI 213741	Walapai	Upland Yuman	IA 04	147.67	105	202
			NM 04	119.37	69	145
			NM 05	114.90	74	172
PI 213737	Navajo	Western Apache	IA 04	164.94	105	204
			NM 04	122.53	89	158
			NM 05	133.70	95	162
PI 213738	Navajo	Western Apache	IA 04	141.33	95	179
			NM 04	104.77	75	137
			NM 05	114.05	68	148
PI 213739	Navajo	Western Apache	IA 04	172.68	105	240
			NM 04	128.00	82	168
			NM 05	134.75	78	200
PI 213740	Navajo	Western Apache	IA 04	178.94	135	236
			NM 04	132.22	111	157
			NM 05	153.05	121	185
PI 218160	Navajo	Western Apache	IA 04	149.72	95	210
			NM 04	105.60	74	144
			NM 05	112.85	72	153
PI 218161	Navajo	Western Apache	IA 04	165.11	120	223
			NM 04	113.73	87	141
			NM 05	118.40	89	151
PI 218162	Navajo	Western Apache	IA 04	187.50	120	276
			NM 04	120.35	81	161
			NM 05	134.65	110	179
PI 218163	Navajo	Western Apache	IA 04	172.39	110	207
			NM 04	103.28	72	123
			NM 05	113.70	54	145
PI 218164	Navajo	Western Apache	IA 04	165.67	80	237
			NM 04	115.39	69	157
			NM 05	124.70	75	177

Table 26: continued

Accession number	Ethnic group	Language group	Environment	Plant height (cm)		
				Average	Minimum	Maximum
PI 218165	Navajo	Western Apache	IA 04	149.78	110	205
			NM 04	102.69	60	149
			NM 05	120.55	101	155
PI 218166	Navajo	Western Apache	IA 04	147.28	70	215
			NM 04	109.00	84	153
			NM 05	131.05	96	153
PI 222285	Navajo	Western Apache	IA 04	94.67	65	157
			NM 04	76.87	41	99
			NM 05	71.84	32	98
PI 311229	Navajo	Western Apache	IA 04	147.50	110	185
			NM 04	128.19	75	159
			NM 05	125.74	100	149
PI 503568	Navajo	Western Apache	IA 04	165.11	120	230
			NM 04	134.61	92	158
			NM 05	125.65	96	149
PI 213736	San Carlos Apache	Western Apache	IA 04	184.22	125	229
			NM 04	104.28	75	137
			NM 05	152.05	127	181
PI 213728	White Mountain Apache	Western Apache	IA 04	204.33	150	252
			NM 04	155.33	123	189
			NM 05	154.06	103	208
PI 213729	White Mountain Apache	Western Apache	IA 04	218.00	170	261
			NM 04	167.19	71	215
			NM 05	178.47	138	205
PI 213730	White Mountain Apache	Western Apache	IA 04	154.50	110	273
			NM 04	112.32	89	129
			NM 05	104.05	60	133
PI 213767	Unknown		IA 04	205.59	150	247
			NM 04	158.82	116	198
			NM 05	143.45	101	201
NSL 2830	Mexico		IA 04	257.67	200	305
			NM 04	156.89	121	200
			NM 05	196.60	152	260
NSL 283388	Mexico		IA 04	276.13	225	331
			NM 04	181.65	128	240
			NM 05	217.35	154	276
PI 420245	Mexico		IA 04	235.67	210	287
			NM 04	179.72	134	225
			NM 05	184.70	150	225
PI 420252	Mexico		IA 04	285.00	225	350
			NM 04	197.55	152	231
			NM 05	203.79	146	257
PI 474206	Mexico		IA 04	258.06	200	310
			NM 04	198.91	135	244
			NM 05	229.85	158	315

Table 26: continued

Accession number	Ethnic group	Language group	Environment	Plant height (cm)		
				Average	Minimum	Maximum
PI 474209	Mexico		IA 04	254.44	200	295
			NM 04	177.77	132	298
			NM 05	210.70	140	275
PI 484413	Mexico		IA 04	182.56	144	255
			NM 04	133.96	87	170
			NM 05	129.00	103	151
PI 484433	Mexico		IA 04	235.28	195	297
			NM 04	166.44	118	206
			NM 05	158.30	103	241
PI 484482	Mexico		IA 04	232.78	190	295
			NM 04	180.15	131	237
			NM 05	175.33	107	211
PI 485116	Mexico		IA 04	187.78	140	275
			NM 04	144.68	85	182
			NM 05	142.30	51	193
PI 490921	Mexico		IA 04	230.00	130	290
			NM 04	171.96	133	241
			NM 05	189.16	114	236
PI 490973	Mexico		IA 04	300.18	235	340
			NM 04	230.50	184	292
			NM 05	244.79	200	287
PI 629147	Mexico		IA 04	340.22	290	430
			NM 04	256.20	188	309
			NM 05	278.40	224	331
Ames 26908	Control		IA 04	255.00	215	280
			NM 04	189.00	154	217
			NM 05	197.05	169	230
Ames 6048	Control		IA 04	208.06	135	270
			NM 04	192.33	135	255
			NM 05	171.78	136	201
Ames 19097	Control		IA 04	213.50	200	225
			NM 04	167.19	158	185
			NM 05	184.95	107	231
PI 213697	Control		IA 04	214.17	145	250
			NM 04	152.82	110	195
			NM 05	150.13	90	180
PI 213712	Control		IA 04	233.83	190	315
			NM 04	163.24	118	199
			NM 05	174.40	136	227
PI 213732	Control		IA 04	187.67	108	235
			NM 04	137.00	118	169
			NM 05	169.50	137	217
PI 213757	Control		IA 04	222.78	155	260
			NM 04	158.56	119	179
			NM 05	173.70	92	223

Table 26: continued

Accession number	Ethnic group	Language group	Environment	Plant height (cm)		
				Average	Minimum	Maximum
PI 217405	Control		IA 04	224.33	200	260
			NM 04	184.39	127	241
			NM 05	220.10	185	259
PI 217408	Control		IA 04	157.83	120	206
			NM 04	111.24	85	134
			NM 05	109.25	64	136
PI 217411	Control		IA 04	139.67	109	193
			NM 04	103.77	72	145
			NM 05	113.20	84	151
PI 311243	Control		IA 04	279.61	240	315
			NM 04	200.23	128	258
			NM 05	213.95	141	284
PI 408705	Control		IA 04	227.78	195	260
			NM 04	163.17	114	211
			NM 05	166.85	111	236
PI 508270	Control		IA 04	301.67	230	364
			NM 04	223.54	137	277
PI 550563	Control		IA 04	279.50	230	343
			NM 04	201.22	175	224

Table 27: Accession mean, minimum and maximum for number of tassel branches in the three environments

Accession number	Ethnic group	Language group	Environment	Number of branches		
				Average	Minimum	Maximum
PI 218140	Acoma Pueblo	Keresan	IA 04	20.71	13	29
			NM 04	19.28	10	27
			NM 05	14.81	8	21
PI 218141	Acoma Pueblo	Keresan	IA 04	16.87	8	28
			NM 04	17.28	13	25
			NM 05	14.72	7	22
PI 218167	Acoma Pueblo	Keresan	IA 04	21.38	11	29
			NM 04	24.78	15	36
			NM 05	16.90	11	23
PI 218168	Acoma Pueblo	Keresan	IA 04	21.00	11	30
			NM 04	19.44	13	29
			NM 05	15.74	9	22
PI 218131	Cochiti Pueblo	Keresan	IA 04	19.53	12	29
			NM 04	21.94	16	37
			NM 05	16.10	10	21
PI 218145	Cochiti Pueblo	Keresan	IA 04	19.53	13	32
			NM 04	21.28	13	35
			NM 05	15.05	8	20
PI 218150	Cochiti Pueblo	Keresan	IA 04	25.33	20	32
			NM 04	22.94	16	33
			NM 05	16.16	9	21
PI 218151	Cochiti Pueblo	Keresan	IA 04	16.31	12	23
			NM 04	17.44	11	26
			NM 05	14.32	7	21
PI 218133	Laguna Pueblo	Keresan	IA 04	22.00	9	35
			NM 04	27.22	16	38
			NM 05	20.56	13	44
PI 218146	Laguna Pueblo	Keresan	IA 04	17.06	11	24
			NM 04	17.67	11	26
			NM 05	14.50	10	22
PI 218147	Laguna Pueblo	Keresan	IA 04	22.41	16	36
			NM 04	23.33	19	29
			NM 05	17.70	13	23
PI 218169	Laguna Pueblo	Keresan	IA 04	16.08	7	28
			NM 04	19.06	10	30
			NM 05	15.00	7	25
PI 218170	Laguna Pueblo	Keresan	IA 04	12.40	6	19
			NM 04	18.22	11	30
			NM 05	14.90	10	20
PI 218153	San Felipe Pueblo	Keresan	IA 04	20.44	13	30
			NM 04	16.56	5	27
			NM 05	13.05	1	20
PI 218154	San Felipe Pueblo	Keresan	IA 04	24.00	13	37
			NM 04	23.89	13	34
			NM 05	17.84	12	23

Table 27: continued

Accession number	Ethnic group	Language group	Environment	Number of branches		
				Average	Minimum	Maximum
PI 218130	Santo Domingo Pueblo	Keresan	IA 04	18.58	13	25
			NM 04	18.44	9	30
			NM 05	13.87	8	22
PI 218143	Santo Domingo Pueblo	Keresan	IA 04	19.79	13	26
			NM 04	19.56	12	27
			NM 05	16.55	11	23
PI 218155	Santo Domingo Pueblo	Keresan	IA 04	18.92	11	27
			NM 04	21.00	13	38
			NM 05	17.42	9	25
PI 218156	Santo Domingo Pueblo	Keresan	IA 04	17.53	6	25
			NM 04	21.61	12	35
			NM 05	15.75	9	21
PI 218139	Zia Pueblo	Keresan	IA 04	24.13	16	34
			NM 04	21.00	12	25
			NM 05	19.85	10	40
PI 218158	Zia Pueblo	Keresan	IA 04	22.57	8	33
			NM 04	19.33	12	28
			NM 05	18.94	14	22
PI 218159	Zia Pueblo	Keresan	IA 04	20.31	10	30
			NM 04	20.33	10	30
			NM 05	17.35	8	29
PI 218188	Zia Pueblo	Keresan	IA 04	19.00	8	30
			NM 04	18.17	10	32
			NM 05	13.95	5	25
PI 218138	Isleta Pueblo	Tanoan	IA 04	24.58	15	42
			NM 04	23.72	15	34
			NM 05	18.06	7	31
PI 218144	Isleta Pueblo	Tanoan	IA 04	18.88	10	28
			NM 04	18.06	10	31
			NM 05	13.85	5	19
PI 218148	Isleta Pueblo	Tanoan	IA 04	18.47	10	26
			NM 04	18.17	8	30
			NM 05	13.75	5	19
PI 218171	Jemez Pueblo	Tanoan	IA 04	19.00	13	25
			NM 04	20.94	9	32
			NM 05	17.50	12	22
PI 218172	Jemez Pueblo	Tanoan	IA 04	19.36	9	28
			NM 04	17.18	10	26
			NM 05	13.80	7	23
PI 218173	Jemez Pueblo	Tanoan	IA 04	22.29	14	33
			NM 04	19.17	12	32
			NM 05	16.15	10	21
PI 218135	Picuris Pueblo	Tanoan	IA 04	13.65	7	19
			NM 04	17.94	8	29
			NM 05	12.95	7	24

Table 27: continued

Accession number	Ethnic group	Language group	Environment	Number of branches		
				Average	Minimum	Maximum
PI 218142	Picuris Pueblo	Tanoan	IA 04	14.94	6	24
			NM 04	22.83	11	38
			NM 05	13.16	5	25
PI 218157	Santa Clara Pueblo	Tanoan	IA 04	20.87	12	31
			NM 04	21.61	13	28
			NM 05	16.11	10	25
PI 218149	Taos Pueblo	Tanoan	IA 04	14.88	5	25
			NM 04	19.94	10	29
			NM 05	17.65	7	28
PI 218152	Taos Pueblo	Tanoan	IA 04	16.88	6	31
			NM 04	19.17	10	25
			NM 05	19.25	13	27
PI 476868	Taos Pueblo	Tanoan	IA 04	15.19	9	23
			NM 04	16.67	7	24
			NM 05	13.00	3	20
PI 218134	Tesuque Pueblo	Tanoan	IA 04	21.42	13	30
			NM 04	21.17	14	30
			NM 05	17.35	12	32
PI 218136	Tesuque Pueblo	Tanoan	IA 04	11.00	4	21
			NM 04	12.61	5	25
			NM 05	12.83	6	18
PI 218137	Tesuque Pueblo	Tanoan	IA 04	16.75	6	36
			NM 04	16.17	7	24
			NM 05	13.95	7	23
Zuni	Zuni	Zuni	IA 04	21.33	12	32
			NM 04	23.67	14	34
			NM 05	15.60	7	27
Ames 22643	Hopi	Hopi	IA 04	11.29	5	22
			NM 04	11.83	6	19
			NM 05	12.00	4	21
NSL 67047	Hopi	Hopi	IA 04	21.40	15	32
			NM 04	18.67	12	30
			NM 05	19.55	11	35
NSL 67048	Hopi	Hopi	IA 04	20.67	10	33
			NM 04	20.33	14	29
			NM 05	19.50	3	39
NSL 67049	Hopi	Hopi	IA 04	21.71	10	32
			NM 04	17.88	11	25
			NM 05	20.00	10	43
NSL 67051	Hopi	Hopi	IA 04	22.86	9	40
			NM 04	22.71	16	31
			NM 05	19.11	6	34
NSL 67052	Hopi	Hopi	IA 04	22.00	14	34
			NM 04	20.67	11	32
			NM 05	17.35	10	26

Table 27: continued

Accession number	Ethnic group	Language group	Environment	Number of branches		
				Average	Minimum	Maximum
NSL 67053	Hopi	Hopi	IA 04	20.13	13	28
			NM 04	20.39	13	30
			NM 05	17.70	12	26
NSL 67054	Hopi	Hopi	IA 04	19.75	8	28
			NM 04	20.22	15	26
			NM 05	15.05	9	22
NSL 67055	Hopi	Hopi	IA 04	22.33	11	32
			NM 04	20.22	8	30
			NM 05	18.20	6	26
NSL 67056	Hopi	Hopi	IA 04	15.55	10	27
			NM 04	18.78	12	25
			NM 05	14.16	4	23
NSL 67057	Hopi	Hopi	IA 04	13.73	6	22
			NM 04	13.33	3	29
			NM 05	10.37	5	15
NSL 67058	Hopi	Hopi	IA 04	13.61	7	20
			NM 04	14.72	10	22
			NM 05	13.15	5	22
NSL 67059	Hopi	Hopi	IA 04	13.92	9	26
			NM 04	16.50	10	23
			NM 05	14.50	7	21
NSL 67060	Hopi	Hopi	IA 04	17.87	11	25
			NM 04	18.67	11	34
			NM 05	15.21	9	26
NSL 67061	Hopi	Hopi	IA 04	18.27	6	26
			NM 04	20.67	8	31
			NM 05	18.60	7	29
NSL 67062	Hopi	Hopi	IA 04	20.33	12	28
			NM 04	17.56	11	22
			NM 05	14.63	9	20
NSL 67063	Hopi	Hopi	IA 04	19.47	10	34
			NM 04	21.56	14	32
			NM 05	15.85	9	24
NSL 67064	Hopi	Hopi	IA 04	11.07	6	15
			NM 04	13.39	5	18
			NM 05	9.60	5	15
NSL 67065	Hopi	Hopi	IA 04	17.64	12	27
			NM 04	20.28	13	26
			NM 05	16.68	10	24
NSL 67066	Hopi	Hopi	IA 04	12.85	5	21
			NM 04	16.11	9	21
			NM 05	12.55	6	20
NSL 67068	Hopi	Hopi	IA 04	25.31	14	38
			NM 04	22.33	14	35
			NM 05	17.63	9	27

Table 27: continued

Accession number	Ethnic group	Language group	Environment	Number of branches		
				Average	Minimum	Maximum
NSL 68323	Hopi	Hopi	IA 04	11.85	8	17
			NM 04	14.06	7	23
			NM 05	11.60	6	17
NSL 68324	Hopi	Hopi	IA 04	10.63	7	16
			NM 04	9.89	2	20
			NM 05	8.40	3	16
NSL 68325	Hopi	Hopi	IA 04	20.79	8	31
			NM 04	22.61	13	38
			NM 05	15.50	11	19
NSL 68326	Hopi	Hopi	IA 04	14.25	9	20
			NM 04	12.56	7	19
			NM 05	10.85	6	15
NSL 68327	Hopi	Hopi	IA 04	11.31	7	17
			NM 04	10.93	5	23
			NM 05	10.45	6	18
NSL 68329	Hopi	Hopi	IA 04	16.43	8	25
			NM 04	17.11	11	26
			NM 05	13.55	6	23
NSL 68330	Hopi	Hopi	IA 04	10.30	3	15
			NM 04	13.44	3	27
			NM 05	8.26	3	19
NSL 68331	Hopi	Hopi	IA 04	14.94	9	24
			NM 04	17.06	9	22
			NM 05	15.65	6	26
NSL 68332	Hopi	Hopi	IA 04	9.93	3	14
			NM 04	8.94	2	15
			NM 05	7.76	3	12
NSL 68334	Hopi	Hopi	IA 04	10.81	4	18
			NM 04	13.94	10	19
			NM 05	11.70	2	19
NSL 68335	Hopi	Hopi	IA 04	16.39	9	32
			NM 04	22.95	15	40
			NM 05	20.05	8	30
NSL 68336	Hopi	Hopi	IA 04	19.69	8	40
			NM 04	19.56	13	25
			NM 05	17.68	7	29
PI 213733	Hopi	Hopi	IA 04	12.41	6	22
			NM 04	14.17	4	27
			NM 05	11.11	5	22
PI 213734	Hopi	Hopi	IA 04	11.63	6	20
			NM 04	15.56	11	26
			NM 05	12.79	9	18
PI 213735	Hopi	Hopi	IA 04	15.46	9	25
			NM 04	23.00	12	44
			NM 05	16.24	8	24

Table 27: continued

Accession number	Ethnic group	Language group	Environment	Number of branches		
				Average	Minimum	Maximum
PI 218174	Hopi	Hopi	IA 04	9.33	5	15
			NM 04	12.61	4	23
			NM 05	11.05	3	22
PI 218175	Hopi	Hopi	IA 04	13.40	4	22
			NM 04	16.61	4	29
			NM 05	12.20	8	22
PI 218176	Hopi	Hopi	IA 04	13.33	5	27
			NM 04	16.11	6	23
			NM 05	12.56	5	19
PI 218178	Hopi	Hopi	IA 04	13.65	7	22
			NM 04	19.39	7	32
			NM 05	14.56	6	24
PI 420247	Hopi	Hopi	IA 04	13.12	8	24
			NM 04	16.22	5	31
			NM 05	12.41	6	20
PI 420248	Hopi	Hopi	IA 04	14.80	6	22
			NM 04	16.89	7	29
			NM 05	12.63	3	22
PI 420250	Hopi	Hopi	IA 04	13.06	3	21
			NM 04	16.94	8	23
			NM 05	12.05	6	20
PI 476869	Hopi	Hopi	IA 04	17.94	11	24
			NM 04	22.00	12	32
			NM 05	14.56	3	23
PI 503562	Hopi	Hopi	IA 04	15.06	5	23
			NM 04	16.83	8	30
			NM 05	14.26	8	21
PI 503564	Hopi	Hopi	IA 04	17.82	7	31
			NM 04	17.72	6	31
			NM 05	13.00	6	22
PI 503565	Hopi	Hopi	IA 04	13.80	8	20
			NM 04	16.17	6	27
			NM 05	11.95	7	18
PI 503566	Hopi	Hopi	IA 04	18.13	4	33
			NM 04	19.00	8	34
			NM 05	18.00	11	24
PI 503567	Hopi	Hopi	IA 04	15.94	9	27
			NM 04	15.44	7	23
			NM 05	11.56	6	18
PI 503563	Pima-Maricopa	Piman	IA 04	16.00	9	23
			NM 04	17.50	10	25
			NM 05	11.45	6	16
PI 420251	Pima-Maricopa	Piman	IA 04	11.22	6	18
			NM 04	11.72	4	15
			NM 05	8.37	3	14

Table 27: continued

Accession number	Ethnic group	Language group	Environment	Number of branches		
				Average	Minimum	Maximum
PI 213714	Tohono O'odham	Piman	IA 04	14.36	6	21
			NM 04	15.56	10	19
			NM 05	12.75	7	18
PI 218179	Tohono O'odham	Piman	IA 04	13.73	8	24
			NM 04	13.28	6	22
			NM 05	10.89	7	22
PI 218180	Tohono O'odham	Piman	IA 04	17.94	6	26
			NM 04	15.83	12	26
			NM 05	13.79	6	22
PI 218181	Tohono O'odham	Piman	IA 04	21.28	13	29
			NM 04	17.44	11	24
			NM 05	16.93	12	26
PI 218182	Tohono O'odham	Piman	IA 04	22.36	11	35
			NM 04	21.44	12	29
			NM 05	19.42	10	27
PI 218183	Tohono O'odham	Piman	IA 04	21.67	9	36
			NM 04	16.56	9	24
			NM 05	13.85	8	21
PI 218184	Tohono O'odham	Piman	IA 04	22.87	10	36
			NM 04	20.29	15	26
			NM 05	17.68	6	31
PI 218185	Tohono O'odham	Piman	IA 04	14.73	5	28
			NM 04	14.78	7	23
			NM 05	12.00	7	17
PI 218189	Tohono O'odham	Piman	IA 04	21.86	11	28
			NM 04	22.11	14	30
			NM 05	16.58	11	22
PI 218190	Tohono O'odham	Piman	IA 04	22.71	16	33
			NM 04	21.17	10	32
			NM 05	20.61	7	28
PI 218191	Tohono O'odham	Piman	IA 04	19.64	8	29
			NM 04	16.50	11	25
			NM 05	15.20	9	24
PI 451716	Tohono O'odham	Piman	IA 04	11.79	8	19
			NM 04	13.22	7	18
			NM 05	10.35	6	14
PI 503573	Tohono O'odham	Piman	IA 04	12.56	5	24
			NM 04	14.44	5	27
			NM 05	11.30	7	18
PI 218186	Mojave	River Yuman	IA 04	12.20	7	19
			NM 04	11.44	7	19
			NM 05	10.55	4	22
PI 218187	Mojave	River Yuman	IA 04	12.47	8	19
			NM 04	10.83	6	19
			NM 05	10.11	6	16

Table 27: continued

Accession number	Ethnic group	Language group	Environment	Number of branches		
				Average	Minimum	Maximum
PI 317674	Havasupai	Upland Yuman	IA 04	16.63	7	23
			NM 04	18.78	12	25
			NM 05	13.53	6	19
PI 317675	Havasupai	Upland Yuman	IA 04	13.50	6	22
			NM 04	13.33	8	27
			NM 05	11.15	5	17
PI 317678	Havasupai	Upland Yuman	IA 04	16.06	9	23
			NM 04	17.28	8	28
			NM 05	13.30	9	20
PI 317679	Havasupai	Upland Yuman	IA 04	15.88	7	27
			NM 04	17.84	12	22
			NM 05	14.75	10	21
PI 476870	Havasupai	Upland Yuman	IA 04	11.75	3	17
			NM 04	16.72	10	26
			NM 05	12.35	4	19
PI 213741	Walapai	Upland Yuman	IA 04	5.54	4	9
			NM 04	7.61	4	11
			NM 05	6.00	3	17
PI 213737	Navajo	Western Apache	IA 04	9.64	5	13
			NM 04	16.33	9	24
			NM 05	10.45	4	16
PI 213738	Navajo	Western Apache	IA 04	12.20	7	18
			NM 04	19.00	7	32
			NM 05	13.50	4	21
PI 213739	Navajo	Western Apache	IA 04	18.69	9	28
			NM 04	18.28	10	27
			NM 05	16.15	3	22
PI 213740	Navajo	Western Apache	IA 04	19.23	13	26
			NM 04	22.44	17	32
			NM 05	20.30	12	28
PI 218160	Navajo	Western Apache	IA 04	19.60	11	31
			NM 04	19.06	7	27
			NM 05	18.05	11	32
PI 218161	Navajo	Western Apache	IA 04	14.56	9	21
			NM 04	16.33	7	29
			NM 05	14.00	5	21
PI 218162	Navajo	Western Apache	IA 04	13.00	6	29
			NM 04	17.67	10	24
			NM 05	14.35	8	21
PI 218163	Navajo	Western Apache	IA 04	13.23	5	20
			NM 04	12.72	4	21
			NM 05	11.16	5	15
PI 218164	Navajo	Western Apache	IA 04	12.08	8	19
			NM 04	12.33	4	26
			NM 05	11.84	6	20

Table 27: continued

Accession number	Ethnic group	Language group	Environment	Number of branches		
				Average	Minimum	Maximum
PI 218165	Navajo	Western Apache	IA 04	15.92	9	21
			NM 04	16.61	7	26
			NM 05	14.53	10	21
PI 218166	Navajo	Western Apache	IA 04	13.31	7	23
			NM 04	13.83	5	22
			NM 05	13.40	6	22
PI 222285	Navajo	Western Apache	IA 04	8.08	5	12
			NM 04	13.83	7	20
			NM 05	9.83	6	16
PI 311229	Navajo	Western Apache	IA 04	19.00	6	30
			NM 04	20.00	10	42
			NM 05	18.05	12	24
PI 503568	Navajo	Western Apache	IA 04	17.14	5	27
			NM 04	16.67	11	23
			NM 05	15.47	6	26
PI 213736	San Carlos Apache	Western Apache	IA 04	8.47	5	12
			NM 04	9.56	6	17
			NM 05	9.20	5	19
PI 213728	White Mountain Apache	Western Apache	IA 04	13.23	8	20
			NM 04	15.72	10	23
			NM 05	15.25	7	26
PI 213729	White Mountain Apache	Western Apache	IA 04	15.00	9	21
			NM 04	20.11	17	30
			NM 05	13.79	7	18
PI 213730	White Mountain Apache	Western Apache	IA 04	13.27	8	18
			NM 04	17.00	14	21
			NM 05	12.11	7	16
PI 213767	Unknown		IA 04	16.93	12	24
			NM 04	20.28	15	30
			NM 05	14.84	9	20
NSL 2830	Mexico		IA 04	14.94	3	24
			NM 04	13.33	8	18
			NM 05	13.00	5	22
NSL 283388	Mexico		IA 04	18.69	12	27
			NM 04	17.39	12	25
			NM 05	15.29	9	24
PI 420245	Mexico		IA 04	17.76	5	28
			NM 04	16.00	11	20
			NM 05	12.60	3	24
PI 420252	Mexico		IA 04	19.50	10	27
			NM 04	17.06	7	23
			NM 05	15.47	8	35
PI 474206	Mexico		IA 04	22.71	17	38
			NM 04	18.56	13	24
			NM 05	15.63	7	28

Table 27: continued

Accession number	Ethnic group	Language group	Environment	Number of branches		
				Average	Minimum	Maximum
PI 474209	Mexico		IA 04	16.56	7	26
			NM 04	14.44	9	24
			NM 05	13.11	8	19
PI 484413	Mexico		IA 04	8.33	3	13
			NM 04	5.33	2	8
			NM 05	7.00	1	18
PI 484433	Mexico		IA 04	12.67	8	22
			NM 04	11.72	5	20
			NM 05	11.20	4	22
PI 484482	Mexico		IA 04	12.08	6	20
			NM 04	10.22	3	17
			NM 05	7.40	5	11
PI 485116	Mexico		IA 04	8.38	3	20
			NM 04	9.39	3	24
			NM 05	4.40	1	8
PI 490921	Mexico		IA 04	24.91	15	35
			NM 04	16.33	10	34
			NM 05	20.46	7	39
PI 490973	Mexico		IA 04	21.88	15	30
			NM 04	16.75	8	27
			NM 05	13.19	6	24
PI 629147	Mexico		IA 04	25.38	14	44
			NM 04	18.59	12	25
			NM 05	16.69	5	27
Ames 26908	Control		IA 04	17.80	10	26
			NM 04	13.33	10	17
			NM 05	12.60	8	20
Ames 6048	Control		IA 04	17.20	10	30
			NM 04	18.94	13	28
			NM 05	16.13	6	24
Ames 19097	Control		IA 04	8.13	5	10
			NM 04	8.61	7	10
			NM 05	8.45	6	13
PI 213697	Control		IA 04	17.57	8	26
			NM 04	15.00	9	18
			NM 05	13.00	6	20
PI 213712	Control		IA 04	23.86	14	33
			NM 04	26.35	15	42
			NM 05	18.35	11	23
PI 213732	Control		IA 04	18.87	8	30
			NM 04	23.28	17	29
			NM 05	16.16	9	26
PI 213757	Control		IA 04	15.67	11	19
			NM 04	14.61	9	22
			NM 05	13.40	7	20

Table 27: continued

Accession number	Ethnic group	Language group	Environment	Number of branches		
				Average	Minimum	Maximum
PI 217405	Control		IA 04	21.73	16	27
			NM 04	20.56	13	29
			NM 05	20.00	8	27
PI 217408	Control		IA 04	11.64	8	18
			NM 04	17.22	12	23
			NM 05	11.80	5	18
PI 217411	Control		IA 04	13.12	6	20
			NM 04	16.61	11	22
			NM 05	11.80	3	18
PI 311243	Control		IA 04	25.76	14	37
			NM 04	24.06	14	32
			NM 05	16.60	11	22
PI 408705	Control		IA 04	19.53	11	30
			NM 04	18.33	11	34
			NM 05	11.50	5	27
PI 508270	Control		IA 04	20.38	14	31
			NM 04	19.33	12	28
PI 550563	Control		IA 04	21.60	12	40
			NM 04	21.50	12	30

Table 28: Accession mean, minimum and maximum for rows per ear in the three environments

Accession number	Ethnic group	Language group	Environment	Row number		
				Average	Minimum	Maximum
PI 218140	Acoma Pueblo	Keresan	IA 04	15.78	12	20
			NM 04	15.57	14	18
			NM 05	15.00	12	16
PI 218141	Acoma Pueblo	Keresan	IA 04	13.60	10	18
			NM 04	13.87	10	18
			NM 05	14.33	12	18
PI 218167	Acoma Pueblo	Keresan	IA 04	14.22	12	18
			NM 04	14.53	12	18
			NM 05	13.88	12	18
PI 218168	Acoma Pueblo	Keresan	IA 04	15.57	14	18
			NM 04	15.86	14	20
			NM 05	14.31	12	18
PI 218131	Cochiti Pueblo	Keresan	IA 04	13.14	10	16
			NM 04	14.40	10	16
			NM 05	13.87	12	16
PI 218145	Cochiti Pueblo	Keresan	IA 04	14.77	12	18
			NM 04	15.29	12	18
			NM 05	15.47	12	18
PI 218150	Cochiti Pueblo	Keresan	IA 04	14.77	12	20
			NM 04	14.93	12	22
			NM 05	14.53	12	18
PI 218151	Cochiti Pueblo	Keresan	IA 04	15.00	12	18
			NM 04	16.13	12	22
			NM 05	16.13	12	20
PI 218133	Laguna Pueblo	Keresan	IA 04	17.14	14	20
			NM 04	18.93	14	24
			NM 05	18.53	14	24
PI 218146	Laguna Pueblo	Keresan	IA 04	14.20	12	20
			NM 04	13.93	12	16
			NM 05	15.50	12	20
PI 218147	Laguna Pueblo	Keresan	IA 04	15.23	12	18
			NM 04	16.77	14	20
			NM 05	16.31	12	22
PI 218169	Laguna Pueblo	Keresan	IA 04	14.30	12	18
			NM 04	15.07	12	18
			NM 05	14.27	12	16
PI 218170	Laguna Pueblo	Keresan	IA 04	14.36	12	16
			NM 04	15.33	12	20
			NM 05	14.71	12	20
PI 218153	San Felipe Pueblo	Keresan	IA 04	12.00	8	16
			NM 04	12.93	10	16
			NM 05	13.86	12	16
PI 218154	San Felipe Pueblo	Keresan	IA 04	16.14	12	22
			NM 04	16.80	12	20
			NM 05	15.88	12	22

Table 28: continued

Accession number	Ethnic group	Language group	Environment	Row number		
				Average	Minimum	Maximum
PI 218130	Santo Domingo Pueblo	Keresan	IA 04	18.33	16	22
			NM 04	17.54	14	20
			NM 05	18.00	12	24
PI 218143	Santo Domingo Pueblo	Keresan	IA 04	15.23	12	22
			NM 04	16.43	14	18
			NM 05	15.08	12	16
PI 218155	Santo Domingo Pueblo	Keresan	IA 04	14.13	10	18
			NM 04	14.27	12	18
			NM 05	14.25	12	20
PI 218156	Santo Domingo Pueblo	Keresan	IA 04	14.60	12	18
			NM 04	15.47	12	20
			NM 05	14.67	12	16
PI 218139	Zia Pueblo	Keresan	IA 04	14.60	12	18
			NM 04	16.00	12	20
			NM 05	14.92	12	20
PI 218158	Zia Pueblo	Keresan	IA 04	14.20	10	16
			NM 04	14.43	10	18
			NM 05	14.93	12	18
PI 218159	Zia Pueblo	Keresan	IA 04	15.00	12	18
			NM 04	14.88	12	20
			NM 05	15.25	12	18
PI 218188	Zia Pueblo	Keresan	IA 04	14.31	12	16
			NM 04	12.67	10	18
			NM 05	13.75	10	18
PI 218138	Isleta Pueblo	Tanoan	IA 04	16.00	12	20
			NM 04	17.47	14	22
			NM 05	16.17	12	24
PI 218144	Isleta Pueblo	Tanoan	IA 04	17.71	10	22
			NM 04	18.80	12	26
			NM 05	17.60	12	22
PI 218148	Isleta Pueblo	Tanoan	IA 04	16.63	14	20
			NM 04	17.47	12	22
			NM 05	16.77	14	18
PI 218171	Jemez Pueblo	Tanoan	IA 04	13.27	10	18
			NM 04	14.13	12	18
			NM 05	13.87	12	18
PI 218172	Jemez Pueblo	Tanoan	IA 04	16.00	12	18
			NM 04	15.60	14	20
			NM 05	14.88	12	18
PI 218173	Jemez Pueblo	Tanoan	IA 04	14.00	12	16
			NM 04	14.93	12	16
			NM 05	15.07	12	18
PI 218135	Picuris Pueblo	Tanoan	IA 04	13.54	10	16
			NM 04	14.86	12	18
			NM 05	15.64	12	22

Table 28: continued

Accession number	Ethnic group	Language group	Environment	Row number		
				Average	Minimum	Maximum
PI 218142	Picuris Pueblo	Tanoan	IA 04	12.60	12	14
			NM 04	13.80	12	16
			NM 05	13.00	12	16
PI 218157	Santa Clara Pueblo	Tanoan	IA 04	15.67	12	20
			NM 04	16.13	12	18
			NM 05	16.50	12	20
PI 218149	Taos Pueblo	Tanoan	IA 04	11.56	10	14
			NM 04	13.87	10	18
			NM 05	13.23	12	16
PI 218152	Taos Pueblo	Tanoan	IA 04	14.00	12	20
			NM 04	13.00	10	18
			NM 05	13.17	10	16
PI 476868	Taos Pueblo	Tanoan	IA 04	12.62	10	16
			NM 04	12.86	8	16
			NM 05	12.91	12	16
PI 218134	Tesuque Pueblo	Tanoan	IA 04	13.83	12	16
			NM 04	14.40	12	18
			NM 05	14.59	8	20
PI 218136	Tesuque Pueblo	Tanoan	IA 04	13.56	10	16
			NM 04	12.93	10	20
			NM 05	13.63	12	16
PI 218137	Tesuque Pueblo	Tanoan	IA 04	13.47	12	18
			NM 04	14.57	12	16
			NM 05	14.63	12	18
Zuni	Zuni	Zuni	IA 04	14.43	12	18
			NM 04	16.53	14	22
			NM 05	16.50	12	20
Ames 22643	Hopi	Hopi	IA 04	13.56	12	16
			NM 04	13.87	10	18
			NM 05	14.38	12	18
NSL 67047	Hopi	Hopi	IA 04	15.33	12	18
			NM 04	14.93	12	18
			NM 05	15.53	14	20
NSL 67048	Hopi	Hopi	IA 04	15.83	14	20
			NM 04	16.13	14	18
			NM 05	15.47	12	20
NSL 67049	Hopi	Hopi	IA 04	18.17	14	24
			NM 04	15.69	12	20
			NM 05	17.57	14	22
NSL 67051	Hopi	Hopi	IA 04	15.73	12	20
			NM 04	16.40	14	20
			NM 05	15.25	12	20
NSL 67052	Hopi	Hopi	IA 04	14.27	12	18
			NM 04	14.53	12	20
			NM 05	15.25	12	18

Table 28: continued

Accession number	Ethnic group	Language group	Environment	Row number		
				Average	Minimum	Maximum
NSL 67053	Hopi	Hopi	IA 04	14.00	12	18
			NM 04	14.67	12	18
			NM 05	14.67	12	18
NSL 67054	Hopi	Hopi	IA 04	14.27	12	16
			NM 04	14.40	12	18
			NM 05	15.33	12	20
NSL 67055	Hopi	Hopi	IA 04	14.00	12	16
			NM 04	14.53	12	20
			NM 05	14.47	12	18
NSL 67056	Hopi	Hopi	IA 04	13.08	12	16
			NM 04	14.00	12	16
			NM 05	13.88	12	16
NSL 67057	Hopi	Hopi	IA 04	13.00	10	20
			NM 04	12.62	10	16
			NM 05	12.67	10	16
NSL 67058	Hopi	Hopi	IA 04	13.00	10	16
			NM 04	13.86	8	18
			NM 05	14.00	12	16
NSL 67059	Hopi	Hopi	IA 04	13.14	12	16
			NM 04	12.86	12	16
			NM 05	14.00	12	18
NSL 67060	Hopi	Hopi	IA 04	12.00	8	14
			NM 04	11.60	8	14
			NM 05	11.75	8	16
NSL 67061	Hopi	Hopi	IA 04	12.80	10	16
			NM 04	13.47	10	20
			NM 05	12.75	10	16
NSL 67062	Hopi	Hopi	IA 04	12.80	8	16
			NM 04	11.87	8	14
			NM 05	12.88	10	14
NSL 67063	Hopi	Hopi	IA 04	12.92	10	16
			NM 04	13.07	8	16
			NM 05	13.18	12	16
NSL 67064	Hopi	Hopi	IA 04	13.71	10	16
			NM 04	13.88	12	20
			NM 05	12.86	10	14
NSL 67065	Hopi	Hopi	IA 04	15.00	12	18
			NM 04	16.13	12	20
			NM 05	14.75	12	18
NSL 67066	Hopi	Hopi	IA 04	12.91	10	16
			NM 04	13.60	12	18
			NM 05	13.76	8	18
NSL 67068	Hopi	Hopi	IA 04	16.53	14	20
			NM 04	17.33	14	22
			NM 05	16.50	14	18

Table 28: continued

Accession number	Ethnic group	Language group	Environment	Row number		
				Average	Minimum	Maximum
NSL 68323	Hopi	Hopi	IA 04	13.00	12	16
			NM 04	12.93	12	16
			NM 05	12.93	8	16
NSL 68324	Hopi	Hopi	IA 04	13.60	10	18
			NM 04	14.27	12	16
			NM 05	12.56	8	16
NSL 68325	Hopi	Hopi	IA 04	14.00	10	18
			NM 04	15.07	12	18
			NM 05	14.59	12	18
NSL 68326	Hopi	Hopi	IA 04	14.15	12	18
			NM 04	13.33	12	20
			NM 05	15.43	12	18
NSL 68327	Hopi	Hopi	IA 04	14.00	10	16
			NM 04	13.60	10	16
			NM 05	14.27	12	16
NSL 68329	Hopi	Hopi	IA 04	12.00	10	14
			NM 04	11.73	8	14
			NM 05	11.88	8	14
NSL 68330	Hopi	Hopi	IA 04	15.09	12	18
			NM 04	15.60	12	20
			NM 05	14.50	12	18
NSL 68331	Hopi	Hopi	IA 04	13.14	12	14
			NM 04	12.93	10	16
			NM 05	13.88	8	20
NSL 68332	Hopi	Hopi	IA 04	12.36	10	14
			NM 04	13.47	12	18
			NM 05	14.92	12	18
NSL 68334	Hopi	Hopi	IA 04	12.33	10	16
			NM 04	12.86	8	18
			NM 05	11.88	10	14
NSL 68335	Hopi	Hopi	IA 04	14.29	10	20
			NM 04	16.57	12	20
			NM 05	15.94	12	20
NSL 68336	Hopi	Hopi	IA 04	13.83	12	16
			NM 04	13.20	10	16
			NM 05	12.82	10	16
PI 213733	Hopi	Hopi	IA 04	14.83	8	18
			NM 04	14.93	12	18
			NM 05	15.14	12	18
PI 213734	Hopi	Hopi	IA 04	13.54	8	18
			NM 04	14.92	10	18
			NM 05	14.40	12	18
PI 213735	Hopi	Hopi	IA 04	12.77	8	16
			NM 04	12.93	10	14
			NM 05	13.20	10	16

Table 28: continued

Accession number	Ethnic group	Language group	Environment	Row number		
				Average	Minimum	Maximum
PI 218174	Hopi	Hopi	IA 04	12.43	10	14
			NM 04	12.40	8	16
			NM 05	13.00	10	18
PI 218175	Hopi	Hopi	IA 04	13.00	10	16
			NM 04	13.73	12	18
			NM 05	14.43	12	20
PI 218176	Hopi	Hopi	IA 04	13.08	12	16
			NM 04	12.40	10	16
			NM 05	13.17	12	16
PI 218178	Hopi	Hopi	IA 04	14.33	12	16
			NM 04	14.80	12	18
			NM 05	13.88	10	16
PI 420247	Hopi	Hopi	IA 04	12.62	8	16
			NM 04	14.27	10	20
			NM 05	14.00	10	20
PI 420248	Hopi	Hopi	IA 04	14.50	12	18
			NM 04	13.29	12	16
			NM 05	14.00	10	18
PI 420250	Hopi	Hopi	IA 04	12.40	10	14
			NM 04	13.47	10	18
			NM 05	13.25	10	16
PI 476869	Hopi	Hopi	IA 04	14.17	10	16
			NM 04	13.86	12	16
			NM 05	14.29	12	18
PI 503562	Hopi	Hopi	IA 04	13.43	12	16
			NM 04	12.86	10	16
			NM 05	14.17	12	20
PI 503564	Hopi	Hopi	IA 04	16.00	14	20
			NM 04	14.40	12	18
			NM 05	15.86	12	22
PI 503565	Hopi	Hopi	IA 04	12.50	10	16
			NM 04	14.33	12	19
			NM 05	13.07	12	18
PI 503566	Hopi	Hopi	IA 04	14.00	12	16
			NM 04	15.00	12	18
			NM 05	14.27	12	16
PI 503567	Hopi	Hopi	IA 04	12.89	12	14
			NM 04	13.20	10	16
			NM 05	12.17	8	16
PI 503563	Pima-Maricopa	Piman	IA 04	12.86	10	14
			NM 04	12.38	10	14
			NM 05	13.00	10	16
PI 420251	Pima-Maricopa	Piman	IA 04	12.40	8	14
			NM 04	12.00	10	14
			NM 05	12.86	12	16

Table 28: continued

Accession number	Ethnic group	Language group	Environment	Row number		
				Average	Minimum	Maximum
PI 213714	Tohono O'odham	Piman	IA 04	11.73	10	14
			NM 04	12.93	10	16
			NM 05	12.00	10	16
PI 218179	Tohono O'odham	Piman	IA 04	13.33	10	16
			NM 04	12.40	8	16
			NM 05	12.82	10	14
PI 218180	Tohono O'odham	Piman	IA 04	15.73	12	20
			NM 04	16.40	14	20
			NM 05	16.25	14	20
PI 218181	Tohono O'odham	Piman	IA 04	14.14	12	18
			NM 04	14.00	10	18
			NM 05	12.83	10	14
PI 218182	Tohono O'odham	Piman	IA 04	13.82	12	16
			NM 04	14.00	10	18
			NM 05	14.25	12	18
PI 218183	Tohono O'odham	Piman	IA 04	16.67	14	20
			NM 04	16.40	14	20
			NM 05	16.27	12	20
PI 218184	Tohono O'odham	Piman	IA 04	14.93	12	18
			NM 04	16.13	12	20
			NM 05	16.14	14	20
PI 218185	Tohono O'odham	Piman	IA 04	11.87	10	14
			NM 04	11.87	10	14
			NM 05	12.25	10	14
PI 218189	Tohono O'odham	Piman	IA 04	17.13	14	24
			NM 04	17.60	14	22
			NM 05	16.88	14	22
PI 218190	Tohono O'odham	Piman	IA 04	14.86	12	18
			NM 04	14.27	12	18
			NM 05	15.00	12	18
PI 218191	Tohono O'odham	Piman	IA 04	15.54	14	18
			NM 04	14.27	12	20
			NM 05	13.85	10	16
PI 451716	Tohono O'odham	Piman	IA 04	14.71	12	18
			NM 04	13.80	10	18
			NM 05	13.38	10	18
PI 503573	Tohono O'odham	Piman	IA 04	11.54	8	14
			NM 04	11.20	8	14
			NM 05	12.75	10	16
PI 218186	Mojave	River Yuman	IA 04	11.08	8	14
			NM 04	10.77	8	14
			NM 05	10.67	8	16
PI 218187	Mojave	River Yuman	IA 04	10.53	8	14
			NM 04	11.07	8	14
			NM 05	9.76	8	12

Table 28: continued

Accession number	Ethnic group	Language group	Environment	Row number		
				Average	Minimum	Maximum
PI 317674	Havasupai	Upland Yuman	IA 04	12.50	10	14
			NM 04	13.07	10	16
			NM 05	12.80	8	16
PI 317675	Havasupai	Upland Yuman	IA 04	12.46	10	14
			NM 04	12.67	10	16
			NM 05	12.86	10	16
PI 317678	Havasupai	Upland Yuman	IA 04	11.60	8	14
			NM 04	12.13	10	14
			NM 05	11.87	10	14
PI 317679	Havasupai	Upland Yuman	IA 04	12.33	10	16
			NM 04	12.93	10	16
			NM 05	12.40	8	16
PI 476870	Havasupai	Upland Yuman	IA 04	12.75	10	16
			NM 04	13.07	10	16
			NM 05	13.63	12	16
PI 213741	Walapai	Upland Yuman	IA 04	11.83	10	14
			NM 04	13.08	10	18
			NM 05	12.40	10	16
PI 213737	Navajo	Western Apache	IA 04	12.22	10	16
			NM 04	11.73	8	16
			NM 05	11.00	10	14
PI 213738	Navajo	Western Apache	IA 04	13.00	12	14
			NM 04	13.29	10	18
			NM 05	13.09	12	16
PI 213739	Navajo	Western Apache	IA 04	14.18	12	18
			NM 04	14.53	10	16
			NM 05	13.53	8	18
PI 213740	Navajo	Western Apache	IA 04	8.00	6	10
			NM 04	8.13	8	10
			NM 05	8.60	8	10
PI 218160	Navajo	Western Apache	IA 04	14.00	10	18
			NM 04	14.29	10	18
			NM 05	14.38	12	20
PI 218161	Navajo	Western Apache	IA 04	13.80	10	20
			NM 04	13.87	12	18
			NM 05	13.86	12	20
PI 218162	Navajo	Western Apache	IA 04	12.92	10	16
			NM 04	14.15	12	16
			NM 05	13.88	12	16
PI 218163	Navajo	Western Apache	IA 04	13.82	12	18
			NM 04	15.20	12	20
			NM 05	14.25	12	18
PI 218164	Navajo	Western Apache	IA 04	13.00	11	16
			NM 04	14.13	12	18
			NM 05	13.73	12	18

Table 28: continued

Accession number	Ethnic group	Language group	Environment	Row number		
				Average	Minimum	Maximum
PI 218165	Navajo	Western Apache	IA 04	12.80	12	16
			NM 04	13.73	12	16
			NM 05	12.88	12	16
PI 218166	Navajo	Western Apache	IA 04	13.27	12	16
			NM 04	13.87	12	18
			NM 05	13.20	10	16
PI 222285	Navajo	Western Apache	IA 04	10.00	10	10
			NM 04	11.17	10	14
			NM 05	10.33	8	12
PI 311229	Navajo	Western Apache	IA 04	15.23	12	20
			NM 04	15.14	12	20
			NM 05	15.07	12	18
PI 503568	Navajo	Western Apache	IA 04	13.09	12	16
			NM 04	13.60	10	16
			NM 05	13.65	10	18
PI 213736	San Carlos Apache	Western Apache	IA 04	9.29	8	12
			NM 04	9.23	8	12
			NM 05	9.85	8	12
PI 213728	White Mountain Apache	Western Apache	IA 04	15.17	12	18
			NM 04	15.20	14	18
			NM 05	16.93	14	20
PI 213729	White Mountain Apache	Western Apache	IA 04	12.29	8	14
			NM 04	13.82	12	16
			NM 05	13.38	12	16
PI 213730	White Mountain Apache	Western Apache	IA 04	11.29	8	14
			NM 04	10.93	10	14
			NM 05	12.18	10	14
PI 213767	Unknown		IA 04	11.50	10	12
			NM 04	12.40	10	14
			NM 05	12.57	10	16
NSL 2830	Mexico		IA 04	8.27	8	10
			NM 04	8.00	6	10
			NM 05	8.13	8	10
NSL 283388	Mexico		IA 04	10.67	8	12
			NM 04	10.86	10	12
			NM 05	10.89	8	14
PI 420245	Mexico		IA 04	11.86	8	14
			NM 04	10.71	8	12
			NM 05	12.14	8	16
PI 420252	Mexico		IA 04	14.55	12	18
			NM 04	14.86	12	20
			NM 05	14.71	12	18
PI 474206	Mexico		IA 04	11.11	8	12
			NM 04	10.40	8	14
			NM 05	12.15	8	16

Table 28: continued

Accession number	Ethnic group	Language group	Environment	Row number		
				Average	Minimum	Maximum
PI 474209	Mexico		IA 04	13.00	12	14
			NM 04	12.80	10	16
			NM 05	13.47	10	18
PI 484413	Mexico		IA 04	11.27	10	12
			NM 04	11.07	8	14
			NM 05	11.85	8	16
PI 484433	Mexico		IA 04	12.27	10	16
			NM 04	13.60	12	16
			NM 05	12.67	10	14
PI 484482	Mexico		IA 04	11.85	10	16
			NM 04	10.93	8	14
			NM 05	11.00	10	12
PI 485116	Mexico		IA 04	13.50	12	16
			NM 04	13.71	10	18
			NM 05	12.50	10	18
PI 490921	Mexico		IA 04	14.67	10	18
			NM 04	14.00	12	16
			NM 05	14.62	12	18
PI 490973	Mexico		IA 04	11.75	10	14
			NM 04	12.50	12	14
			NM 05	12.29	10	16
PI 629147	Mexico		IA 04	14.00	12	18
			NM 04	15.47	12	20
			NM 05	15.27	14	18
Ames 26908	Control		IA 04	17.87	14	20
			NM 04	17.47	14	22
			NM 05	15.75	14	20
Ames 6048	Control		IA 04	8.50	8	10
			NM 04	8.36	8	10
			NM 05	8.36	8	10
Ames 19097	Control		IA 04	15.85	14	18
			NM 04	15.60	14	18
			NM 05	15.75	14	20
PI 213697	Control		IA 04	15.20	12	20
			NM 04	14.80	12	20
			NM 05	15.43	12	18
PI 213712	Control		IA 04	15.43	12	18
			NM 04	16.13	12	20
			NM 05	15.53	12	20
PI 213732	Control		IA 04	10.14	8	12
			NM 04	10.73	10	12
			NM 05	10.40	8	12
PI 213757	Control		IA 04	8.67	8	12
			NM 04	8.43	8	10
			NM 05	7.87	4	10

Table 28: continued

Accession number	Ethnic group	Language group	Environment	Row number		
				Average	Minimum	Maximum
PI 217405	Control		IA 04	17.50	14	20
			NM 04	17.50	14	20
			NM 05	16.80	12	20
PI 217408	Control		IA 04	8.00	6	10
			NM 04	8.00	6	10
			NM 05	8.43	8	10
PI 217411	Control		IA 04	8.29	6	12
			NM 04	8.80	8	12
			NM 05	8.25	8	10
PI 311243	Control		IA 04	15.14	12	20
			NM 04	15.33	12	22
			NM 05	14.82	12	18
PI 408705	Control		IA 04	18.93	14	26
			NM 04	20.13	16	26
			NM 05	19.93	14	26
PI 508270	Control		IA 04	15.57	12	22
			NM 04	15.57	12	18
PI 550563	Control		IA 04	14.00	12	18
			NM 04	14.47	12	18

Table 29: Accession mean, minimum and maximum for ear diameter in the three environments

Accession number	Ethnic group	Language group	Environment	Ear diameter (mm)		
				Average	Minimum	Maximum
PI 218140	Acoma Pueblo	Keresan	IA 04	34.83	31.6	40.1
			NM 04	34.17	31.7	37.1
			NM 05	34.35	27.5	38.8
PI 218141	Acoma Pueblo	Keresan	IA 04	41.65	35.6	50.6
			NM 04	41.83	35.4	46.6
			NM 05	44.00	39.3	51.5
PI 218167	Acoma Pueblo	Keresan	IA 04	47.33	40.6	57.7
			NM 04	50.44	42.8	61.4
			NM 05	46.28	38.9	52.5
PI 218168	Acoma Pueblo	Keresan	IA 04	40.54	35.5	44.2
			NM 04	40.16	36.3	45.8
			NM 05	39.56	33.3	46.6
PI 218131	Cochiti Pueblo	Keresan	IA 04	41.00	34.5	48.2
			NM 04	44.01	34.0	51.0
			NM 05	43.27	39.3	50.5
PI 218145	Cochiti Pueblo	Keresan	IA 04	35.60	32.2	38.1
			NM 04	36.07	32.7	42.5
			NM 05	37.62	34.7	41.1
PI 218150	Cochiti Pueblo	Keresan	IA 04	38.88	34.2	45.0
			NM 04	40.21	34.8	50.4
			NM 05	42.92	38.3	49.4
PI 218151	Cochiti Pueblo	Keresan	IA 04	40.40	32.5	45.5
			NM 04	42.71	31.9	54.0
			NM 05	43.84	37.8	50.7
PI 218133	Laguna Pueblo	Keresan	IA 04	46.67	39.8	57.4
			NM 04	47.45	36.7	53.5
			NM 05	51.05	42.8	64.0
PI 218146	Laguna Pueblo	Keresan	IA 04	38.85	32.7	41.7
			NM 04	40.46	35.9	45.4
			NM 05	43.12	30.8	55.4
PI 218147	Laguna Pueblo	Keresan	IA 04	42.98	37.2	55.0
			NM 04	43.98	35.4	52.6
			NM 05	45.43	42.6	48.1
PI 218169	Laguna Pueblo	Keresan	IA 04	44.39	37.4	54.1
			NM 04	44.15	36.2	52.6
			NM 05	43.85	37.2	52.0
PI 218170	Laguna Pueblo	Keresan	IA 04	37.45	32.7	45.3
			NM 04	41.39	31.2	49.9
			NM 05	39.79	33.8	46.8
PI 218153	San Felipe Pueblo	Keresan	IA 04	34.61	29.1	39.0
			NM 04	34.89	31.4	39.0
			NM 05	36.99	31.4	42.5
PI 218154	San Felipe Pueblo	Keresan	IA 04	46.04	37.9	54.7
			NM 04	49.06	42.5	55.8
			NM 05	48.01	43.2	54.1

Table 29: continued

Accession number	Ethnic group	Language group	Environment	Ear diameter (mm)		
				Average	Minimum	Maximum
PI 218130	Santo Domingo Pueblo	Keresan	IA 04	44.13	38.2	52.9
			NM 04	42.83	37.8	53.9
			NM 05	45.49	36.5	53.8
PI 218143	Santo Domingo Pueblo	Keresan	IA 04	40.50	35.0	50.2
			NM 04	40.46	36.9	45.6
			NM 05	39.88	33.2	46.3
PI 218155	Santo Domingo Pueblo	Keresan	IA 04	40.45	34.8	45.7
			NM 04	43.77	38.6	51.9
			NM 05	43.28	39.7	46.7
PI 218156	Santo Domingo Pueblo	Keresan	IA 04	39.07	35.3	43.0
			NM 04	41.47	32.8	46.6
			NM 05	41.55	36.4	45.8
PI 218139	Zia Pueblo	Keresan	IA 04	41.20	33.9	49.0
			NM 04	45.01	37.2	52.1
			NM 05	46.81	39.3	56.4
PI 218158	Zia Pueblo	Keresan	IA 04	41.22	38.0	44.1
			NM 04	40.99	24.0	47.4
			NM 05	41.48	35.1	47.4
PI 218159	Zia Pueblo	Keresan	IA 04	42.76	37.6	50.8
			NM 04	42.58	37.7	46.7
			NM 05	44.21	40.3	49.5
PI 218188	Zia Pueblo	Keresan	IA 04	39.41	34.5	46.2
			NM 04	37.95	28.7	44.4
			NM 05	40.21	35.7	44.7
PI 218138	Isleta Pueblo	Tanoan	IA 04	48.62	40.8	57.1
			NM 04	52.33	44.5	64.0
			NM 05	49.96	41.3	54.6
PI 218144	Isleta Pueblo	Tanoan	IA 04	44.96	32.9	51.5
			NM 04	48.77	35.3	57.8
			NM 05	48.96	44.0	53.7
PI 218148	Isleta Pueblo	Tanoan	IA 04	44.84	39.1	48.4
			NM 04	46.01	37.4	52.7
			NM 05	49.12	43.9	53.4
PI 218171	Jemez Pueblo	Tanoan	IA 04	47.76	38.2	53.9
			NM 04	49.15	40.7	54.0
			NM 05	49.10	43.2	56.8
PI 218172	Jemez Pueblo	Tanoan	IA 04	49.30	41.5	59.9
			NM 04	51.74	45.9	61.0
			NM 05	50.79	39.5	55.2
PI 218173	Jemez Pueblo	Tanoan	IA 04	42.16	37.0	46.9
			NM 04	44.03	37.1	48.6
			NM 05	43.94	34.9	49.1
PI 218135	Picuris Pueblo	Tanoan	IA 04	40.95	36.4	46.2
			NM 04	43.06	37.2	46.5
			NM 05	46.02	38.4	53.9

Table 29: continued

Accession number	Ethnic group	Language group	Environment	Ear diameter (mm)		
				Average	Minimum	Maximum
PI 218142	Picuris Pueblo	Tanoan	IA 04	39.67	32.9	47.4
			NM 04	43.36	31.7	50.5
			NM 05	43.59	38.1	53.5
PI 218157	Santa Clara Pueblo	Tanoan	IA 04	41.54	34.6	45.5
			NM 04	43.35	36.4	49.3
			NM 05	42.95	38.5	47.3
PI 218149	Taos Pueblo	Tanoan	IA 04	39.07	34.4	41.2
			NM 04	42.86	35.9	50.9
			NM 05	43.49	38.5	46.9
PI 218152	Taos Pueblo	Tanoan	IA 04	45.47	39.5	51.3
			NM 04	41.57	31.0	45.8
			NM 05	43.74	37.9	52.2
PI 476868	Taos Pueblo	Tanoan	IA 04	37.82	33.0	42.4
			NM 04	37.84	34.5	42.0
			NM 05	40.72	37.1	44.8
PI 218134	Tesuque Pueblo	Tanoan	IA 04	43.10	40.0	49.5
			NM 04	44.29	41.1	49.5
			NM 05	43.85	35.2	48.3
PI 218136	Tesuque Pueblo	Tanoan	IA 04	34.92	28.2	42.3
			NM 04	35.39	30.9	44.1
			NM 05	36.87	33.7	40.5
PI 218137	Tesuque Pueblo	Tanoan	IA 04	39.41	30.9	50.7
			NM 04	40.99	37.3	45.8
			NM 05	40.42	33.6	47.1
Zuni	Zuni	Zuni	IA 04	40.02	35.0	45.7
			NM 04	40.87	35.4	47.9
			NM 05	42.72	37.1	48.5
Ames 22643	Hopi	Hopi	IA 04	32.97	30.3	35.5
			NM 04	34.38	30.0	38.1
			NM 05	34.84	30.0	40.8
NSL 67047	Hopi	Hopi	IA 04	52.34	46.6	57.8
			NM 04	49.28	44.1	57.3
			NM 05	52.08	44.7	61.0
NSL 67048	Hopi	Hopi	IA 04	55.35	50.2	61.3
			NM 04	50.89	36.6	58.0
			NM 05	51.14	42.9	61.8
NSL 67049	Hopi	Hopi	IA 04	57.71	52.4	64.4
			NM 04	47.77	36.6	54.7
			NM 05	52.61	41.3	57.0
NSL 67051	Hopi	Hopi	IA 04	50.58	44.2	57.5
			NM 04	49.09	40.9	57.2
			NM 05	48.46	38.6	57.5
NSL 67052	Hopi	Hopi	IA 04	51.21	42.0	58.1
			NM 04	49.83	44.8	52.9
			NM 05	52.76	48.3	58.1

Table 29: continued

Accession number	Ethnic group	Language group	Environment	Ear diameter (mm)		
				Average	Minimum	Maximum
NSL 67053	Hopi	Hopi	IA 04	41.85	37.9	48.1
			NM 04	43.63	35.8	48.2
			NM 05	43.32	38.7	48.1
NSL 67054	Hopi	Hopi	IA 04	39.94	33.4	47.7
			NM 04	41.00	28.4	47.5
			NM 05	42.05	32.3	49.8
NSL 67055	Hopi	Hopi	IA 04	47.39	37.3	54.2
			NM 04	48.89	43.1	56.6
			NM 05	49.36	37.0	56.4
NSL 67056	Hopi	Hopi	IA 04	38.51	31.7	43.5
			NM 04	41.20	34.7	46.7
			NM 05	41.24	34.1	49.2
NSL 67057	Hopi	Hopi	IA 04	41.28	29.9	52.2
			NM 04	40.06	36.4	44.9
			NM 05	42.25	35.4	53.3
NSL 67058	Hopi	Hopi	IA 04	39.01	35.8	42.5
			NM 04	39.96	33.4	44.6
			NM 05	38.95	31.9	47.6
NSL 67059	Hopi	Hopi	IA 04	41.41	34.8	50.4
			NM 04	39.04	31.8	45.1
			NM 05	41.50	33.3	47.6
NSL 67060	Hopi	Hopi	IA 04	39.41	32.0	44.8
			NM 04	38.81	30.8	46.7
			NM 05	39.33	33.8	46.2
NSL 67061	Hopi	Hopi	IA 04	37.08	29.2	45.8
			NM 04	38.82	33.5	56.1
			NM 05	38.93	33.2	43.7
NSL 67062	Hopi	Hopi	IA 04	45.65	39.1	53.2
			NM 04	44.67	38.8	49.3
			NM 05	45.65	39.6	50.7
NSL 67063	Hopi	Hopi	IA 04	45.12	40.4	51.5
			NM 04	45.52	38.9	49.0
			NM 05	47.32	41.6	51.7
NSL 67064	Hopi	Hopi	IA 04	40.51	31.2	47.7
			NM 04	41.51	34.7	49.3
			NM 05	41.12	38.6	48.4
NSL 67065	Hopi	Hopi	IA 04	39.02	32.9	49.4
			NM 04	39.22	34.7	46.3
			NM 05	40.42	34.1	47.8
NSL 67066	Hopi	Hopi	IA 04	44.27	36.6	49.3
			NM 04	43.55	29.7	51.9
			NM 05	44.79	36.1	52.1
NSL 67068	Hopi	Hopi	IA 04	54.66	49.8	63.9
			NM 04	53.18	48.1	59.1
			NM 05	50.97	40.9	55.9

Table 29: continued

Accession number	Ethnic group	Language group	Environment	Ear diameter (mm)		
				Average	Minimum	Maximum
NSL 68323	Hopi	Hopi	IA 04	34.17	30.0	39.5
			NM 04	34.42	30.3	39.7
			NM 05	35.17	25.0	41.4
NSL 68324	Hopi	Hopi	IA 04	35.96	30.5	39.4
			NM 04	37.47	34.6	41.2
			NM 05	37.26	29.3	43.1
NSL 68325	Hopi	Hopi	IA 04	43.17	34.4	49.1
			NM 04	45.29	40.9	51.6
			NM 05	42.89	38.3	48.9
NSL 68326	Hopi	Hopi	IA 04	40.63	37.2	43.3
			NM 04	42.45	37.3	47.7
			NM 05	40.60	35.3	46.7
NSL 68327	Hopi	Hopi	IA 04	39.41	31.6	46.4
			NM 04	41.15	30.5	47.6
			NM 05	40.49	36.1	45.8
NSL 68329	Hopi	Hopi	IA 04	42.91	39.7	47.5
			NM 04	43.00	35.4	49.7
			NM 05	41.58	36.2	46.1
NSL 68330	Hopi	Hopi	IA 04	40.14	35.9	44.4
			NM 04	39.93	28.2	46.3
			NM 05	41.24	34.3	46.7
NSL 68331	Hopi	Hopi	IA 04	36.92	32.3	42.6
			NM 04	37.85	33.1	42.9
			NM 05	40.54	33.0	51.5
NSL 68332	Hopi	Hopi	IA 04	36.59	27.0	42.2
			NM 04	39.85	35.6	46.5
			NM 05	41.78	36.2	49.2
NSL 68334	Hopi	Hopi	IA 04	36.77	31.8	40.5
			NM 04	39.09	32.8	44.5
			NM 05	40.33	36.5	44.7
NSL 68335	Hopi	Hopi	IA 04	49.86	43.1	55.2
			NM 04	46.72	40.3	53.4
			NM 05	49.09	43.2	55.6
NSL 68336	Hopi	Hopi	IA 04	50.53	46.6	54.5
			NM 04	49.51	39.0	57.5
			NM 05	50.31	43.0	55.9
PI 213733	Hopi	Hopi	IA 04	33.55	30.0	37.7
			NM 04	34.20	28.1	40.1
			NM 05	36.88	32.9	40.7
PI 213734	Hopi	Hopi	IA 04	35.47	30.7	39.8
			NM 04	38.08	31.3	44.4
			NM 05	38.51	32.8	43.6
PI 213735	Hopi	Hopi	IA 04	38.02	33.7	46.8
			NM 04	38.17	33.9	40.7
			NM 05	39.08	33.2	43.4

Table 29: continued

Accession number	Ethnic group	Language group	Environment	Ear diameter (mm)		
				Average	Minimum	Maximum
PI 218174	Hopi	Hopi	IA 04	35.86	29.4	40.8
			NM 04	36.13	30.3	40.9
			NM 05	37.61	29.9	44.5
PI 218175	Hopi	Hopi	IA 04	37.95	33.0	41.9
			NM 04	40.15	33.7	50.4
			NM 05	42.43	37.1	46.8
PI 218176	Hopi	Hopi	IA 04	41.58	33.8	51.0
			NM 04	44.32	41.1	50.9
			NM 05	44.16	33.6	53.8
PI 218178	Hopi	Hopi	IA 04	46.38	39.6	55.5
			NM 04	48.63	42.9	54.6
			NM 05	45.84	41.5	51.7
PI 420247	Hopi	Hopi	IA 04	32.80	26.1	36.9
			NM 04	36.22	31.0	42.6
			NM 05	36.60	28.6	42.4
PI 420248	Hopi	Hopi	IA 04	38.19	32.9	48.5
			NM 04	38.38	34.1	47.1
			NM 05	43.18	35.5	51.5
PI 420250	Hopi	Hopi	IA 04	36.46	31.5	48.6
			NM 04	40.11	35.7	47.4
			NM 05	39.86	34.7	45.1
PI 476869	Hopi	Hopi	IA 04	36.07	28.1	42.0
			NM 04	37.46	33.4	42.0
			NM 05	37.99	32.1	45.3
PI 503562	Hopi	Hopi	IA 04	33.70	23.4	37.1
			NM 04	37.24	26.2	44.2
			NM 05	39.55	34.2	45.0
PI 503564	Hopi	Hopi	IA 04	39.51	33.6	54.1
			NM 04	39.78	34.1	47.9
			NM 05	42.38	37.5	51.4
PI 503565	Hopi	Hopi	IA 04	37.78	32.5	46.8
			NM 04	40.48	34.2	48.3
			NM 05	40.66	36.3	49.7
PI 503566	Hopi	Hopi	IA 04	36.27	32.7	40.5
			NM 04	38.23	33.1	43.2
			NM 05	36.73	31.9	41.7
PI 503567	Hopi	Hopi	IA 04	39.38	34.0	43.7
			NM 04	42.21	37.0	50.1
			NM 05	41.70	30.8	47.5
PI 503563	Pima-Maricopa	Piman	IA 04	32.41	27.8	36.8
			NM 04	33.75	29.4	39.7
			NM 05	35.61	29.7	40.6
PI 420251	Pima-Maricopa	Piman	IA 04	32.93	26.2	40.0
			NM 04	33.03	28.6	36.7
			NM 05	34.79	28.7	40.1

Table 29: continued

Accession number	Ethnic group	Language group	Environment	Ear diameter (mm)		
				Average	Minimum	Maximum
PI 213714	Tohono O'odham	Piman	IA 04	33.41	27.4	38.4
			NM 04	34.55	31.1	39.5
			NM 05	34.71	27.3	39.6
PI 218179	Tohono O'odham	Piman	IA 04	36.13	30.7	40.3
			NM 04	34.33	28.9	39.7
			NM 05	36.09	32.2	43.5
PI 218180	Tohono O'odham	Piman	IA 04	50.11	40.5	54.3
			NM 04	49.35	42.4	55.6
			NM 05	49.65	44.1	55.6
PI 218181	Tohono O'odham	Piman	IA 04	47.61	38.5	56.1
			NM 04	47.89	42.8	52.0
			NM 05	45.28	38.5	55.0
PI 218182	Tohono O'odham	Piman	IA 04	49.24	42.5	55.3
			NM 04	46.41	39.6	52.3
			NM 05	49.87	43.1	56.4
PI 218183	Tohono O'odham	Piman	IA 04	50.72	46.3	60.1
			NM 04	48.96	32.8	59.1
			NM 05	50.23	42.1	57.8
PI 218184	Tohono O'odham	Piman	IA 04	50.43	46.0	54.7
			NM 04	49.69	38.7	55.1
			NM 05	50.72	40.2	59.0
PI 218185	Tohono O'odham	Piman	IA 04	33.89	30.9	39.5
			NM 04	33.77	28.9	38.2
			NM 05	35.26	30.8	38.6
PI 218189	Tohono O'odham	Piman	IA 04	50.59	45.4	58.5
			NM 04	48.47	44.2	53.7
			NM 05	51.34	44.3	57.8
PI 218190	Tohono O'odham	Piman	IA 04	49.19	43.6	53.6
			NM 04	45.37	40.1	55.9
			NM 05	48.75	41.9	54.9
PI 218191	Tohono O'odham	Piman	IA 04	50.84	40.7	56.3
			NM 04	48.90	42.6	58.8
			NM 05	52.41	47.1	58.2
PI 451716	Tohono O'odham	Piman	IA 04	34.97	30.5	36.7
			NM 04	34.23	27.7	37.9
			NM 05	36.36	32.9	41.3
PI 503573	Tohono O'odham	Piman	IA 04	32.17	25.6	35.3
			NM 04	32.42	27.6	37.7
			NM 05	34.94	29.3	41.2
PI 218186	Mojave	River Yuman	IA 04	31.40	24.4	39.2
			NM 04	33.67	27.6	39.9
			NM 05	32.37	26.3	39.1
PI 218187	Mojave	River Yuman	IA 04	34.95	30.7	41.3
			NM 04	35.37	30.9	41.6
			NM 05	35.38	31.5	41.6

Table 29: continued

Accession number	Ethnic group	Language group	Environment	Ear diameter (mm)		
				Average	Minimum	Maximum
PI 317674	Havasupai	Upland Yuman	IA 04	38.52	32.2	46.2
			NM 04	42.15	37.3	46.9
			NM 05	40.83	34.3	44.8
PI 317675	Havasupai	Upland Yuman	IA 04	37.63	35.0	40.9
			NM 04	37.89	33.6	42.5
			NM 05	37.63	26.7	43.5
PI 317678	Havasupai	Upland Yuman	IA 04	37.93	26.7	41.6
			NM 04	37.07	32.7	46.0
			NM 05	39.29	32.8	48.7
PI 317679	Havasupai	Upland Yuman	IA 04	38.89	33.9	44.4
			NM 04	39.39	29.7	46.2
			NM 05	40.21	36.8	44.3
PI 476870	Havasupai	Upland Yuman	IA 04	40.68	32.9	46.8
			NM 04	43.73	37.5	50.3
			NM 05	46.16	41.2	52.4
PI 213741	Walapai	Upland Yuman	IA 04	31.47	26.8	37.3
			NM 04	35.07	29.0	38.6
			NM 05	35.97	31.3	40.1
PI 213737	Navajo	Western Apache	IA 04	37.34	32.3	41.2
			NM 04	36.76	33.6	41.0
			NM 05	37.39	32.9	41.1
PI 213738	Navajo	Western Apache	IA 04	35.88	33.5	41.0
			NM 04	38.42	35.4	45.0
			NM 05	38.05	32.9	45.4
PI 213739	Navajo	Western Apache	IA 04	39.35	36.8	41.6
			NM 04	40.69	35.3	44.4
			NM 05	40.76	32.6	47.2
PI 213740	Navajo	Western Apache	IA 04	27.54	23.0	31.7
			NM 04	28.97	27.2	31.0
			NM 05	29.35	27.3	31.4
PI 218160	Navajo	Western Apache	IA 04	40.22	34.2	50.1
			NM 04	41.60	37.0	47.1
			NM 05	40.80	35.5	45.4
PI 218161	Navajo	Western Apache	IA 04	39.61	33.8	44.1
			NM 04	39.68	35.3	48.7
			NM 05	40.49	32.9	55.2
PI 218162	Navajo	Western Apache	IA 04	38.92	33.2	45.2
			NM 04	42.82	34.5	45.8
			NM 05	40.81	37.8	45.7
PI 218163	Navajo	Western Apache	IA 04	36.58	27.9	39.8
			NM 04	40.15	34.8	47.1
			NM 05	41.42	34.4	51.1
PI 218164	Navajo	Western Apache	IA 04	38.30	34.5	44.0
			NM 04	39.35	32.8	46.1
			NM 05	40.71	35.6	47.9

Table 29: continued

Accession number	Ethnic group	Language group	Environment	Ear diameter (mm)		
				Average	Minimum	Maximum
PI 218165	Navajo	Western Apache	IA 04	36.69	31.0	41.4
			NM 04	37.75	30.5	42.5
			NM 05	39.33	35.3	43.1
PI 218166	Navajo	Western Apache	IA 04	37.23	34.0	40.5
			NM 04	37.59	31.2	43.5
			NM 05	38.74	35.8	44.0
PI 222285	Navajo	Western Apache	IA 04	32.60	31.5	33.8
			NM 04	35.80	32.2	43.0
			NM 05	34.69	30.3	39.3
PI 311229	Navajo	Western Apache	IA 04	38.29	33.5	41.8
			NM 04	41.34	32.9	48.1
			NM 05	43.95	36.8	54.1
PI 503568	Navajo	Western Apache	IA 04	36.95	31.7	41.5
			NM 04	39.51	34.7	45.1
			NM 05	38.70	34.6	44.5
PI 213736	San Carlos Apache	Western Apache	IA 04	31.59	26.5	35.2
			NM 04	29.85	24.1	36.5
			NM 05	33.59	30.1	40.8
PI 213728	White Mountain Apache	Western Apache	IA 04	44.07	40.4	48.8
			NM 04	43.65	40.5	49.3
			NM 05	44.39	38.7	49.6
PI 213729	White Mountain Apache	Western Apache	IA 04	37.19	26.2	49.2
			NM 04	39.49	32.8	45.9
			NM 05	41.83	38.4	47.5
PI 213730	White Mountain Apache	Western Apache	IA 04	33.41	23.3	38.4
			NM 04	34.19	24.7	39.4
			NM 05	36.77	30.6	40.3
PI 213767	Unknown		IA 04	39.02	30.7	44.3
			NM 04	42.87	35.9	46.8
			NM 05	41.27	34.6	48.4
NSL 2830	Mexico		IA 04	33.00	28.7	36.5
			NM 04	33.83	28.2	39.1
			NM 05	34.08	30.7	37.8
NSL 283388	Mexico		IA 04	27.43	22.4	33.4
			NM 04	26.55	21.2	29.2
			NM 05	27.44	21.5	32.9
PI 420245	Mexico		IA 04	29.75	24.2	34.6
			NM 04	30.63	27.2	35.5
			NM 05	30.52	22.8	36.5
PI 420252	Mexico		IA 04	40.51	22.5	50.4
			NM 04	41.22	34.3	49.5
			NM 05	40.86	33.5	48.7
PI 474206	Mexico		IA 04	35.57	26.4	41.2
			NM 04	35.46	27.8	45.2
			NM 05	40.09	32.2	46.1

Table 29: continued

Accession number	Ethnic group	Language group	Environment	Ear diameter (mm)		
				Average	Minimum	Maximum
PI 474209	Mexico		IA 04	34.65	31.6	38.0
			NM 04	33.81	27.4	43.5
			NM 05	34.82	30.7	38.7
PI 484413	Mexico		IA 04	32.69	29.9	35.2
			NM 04	31.57	27.6	38.9
			NM 05	33.34	28.4	39.0
PI 484433	Mexico		IA 04	39.05	34.7	43.4
			NM 04	39.31	32.1	45.3
			NM 05	40.13	34.1	44.4
PI 484482	Mexico		IA 04	38.51	35.6	43.8
			NM 04	37.57	31.8	42.9
			NM 05	36.13	30.8	41.8
PI 485116	Mexico		IA 04	38.15	30.1	45.5
			NM 04	39.30	34.0	45.8
			NM 05	36.87	32.4	46.1
PI 490921	Mexico		IA 04	27.88	20.1	38.8
			NM 04	26.70	23.9	29.8
			NM 05	29.94	22.9	38.5
PI 490973	Mexico		IA 04	33.49	29.1	40.5
			NM 04	32.38	23.1	37.6
			NM 05	36.46	30.4	45.0
PI 629147	Mexico		IA 04	40.58	34.3	43.6
			NM 04	42.76	35.6	50.5
			NM 05	42.94	36.2	49.0
Ames 26908	Control		IA 04	51.86	46.6	56.4
			NM 04	49.27	46.4	52.6
			NM 05	49.00	42.2	54.8
Ames 6048	Control		IA 04	36.07	28.5	39.4
			NM 04	34.38	25.5	39.6
			NM 05	36.19	31.6	39.4
Ames 19097	Control		IA 04	48.13	41.6	50.4
			NM 04	49.08	46.2	52.6
			NM 05	49.77	47.3	54.2
PI 213697	Control		IA 04	46.68	42.8	51.1
			NM 04	44.17	38.3	51.5
			NM 05	46.74	40.4	51.4
PI 213712	Control		IA 04	50.32	45.9	55.9
			NM 04	46.29	40.0	51.0
			NM 05	48.69	41.4	54.5
PI 213732	Control		IA 04	39.99	32.0	47.7
			NM 04	39.31	30.7	43.2
			NM 05	41.85	37.1	46.0
PI 213757	Control		IA 04	36.37	34.4	43.7
			NM 04	33.65	28.8	37.1
			NM 05	35.03	32.1	39.0

Table 29: continued

Accession number	Ethnic group	Language group	Environment	Ear diameter (mm)		
				Average	Minimum	Maximum
PI 217405	Control		IA 04	55.17	38.7	65.7
			NM 04	53.31	42.3	63.2
			NM 05	57.26	46.2	65.4
PI 217408	Control		IA 04	33.42	30.5	36.3
			NM 04	33.89	26.5	38.3
			NM 05	35.19	29.3	41.5
PI 217411	Control		IA 04	32.04	27.2	38.3
			NM 04	33.10	28.8	37.5
			NM 05	32.76	26.7	34.9
PI 311243	Control		IA 04	46.82	38.3	52.4
			NM 04	45.37	40.7	55.7
			NM 05	48.10	42.2	53.6
PI 408705	Control		IA 04	50.13	44.6	54.7
			NM 04	47.70	39.7	53.7
			NM 05	47.83	42.6	54.9
PI 508270	Control		IA 04	46.65	40.9	52.9
			NM 04	44.61	30.9	54.5
PI 550563	Control		IA 04	43.22	38.6	46.7
			NM 04	42.59	34.9	48.9