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## Temporal patterns in the evolution of maize agriculture: A geochronological perspective

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### Abstract

Maize (*Zea mays*) is one of the most significant crops in global agriculture, with a complex history of cultivation that spans thousands of years. This review explores the temporal patterns in the evolution of maize agriculture from a geochronological perspective. By synthesizing data from archaeological records, genetic studies, and historical agricultural reports, we trace the domestication, spread, and technological advancements in maize cultivation. The review highlights key periods of change, the influence of climatic and environmental factors, and the role of human innovation in shaping maize agriculture. Future directions for research and the implications for modern agricultural practices are also discussed.

**Keywords:** Maize agriculture, *Zea mays*, domestication

### Introduction

Maize, commonly known as corn, holds a pivotal place in the history of agriculture as one of the most important staple food crops. Its domestication and subsequent agricultural development span over 9,000 years, beginning in the Balsas River Valley of southern Mexico. The process of maize domestication is marked by significant genetic, morphological, and agronomic changes that have allowed it to adapt to diverse environments and meet the growing needs of human populations. Archaeological evidence indicates that maize was first domesticated by indigenous peoples who selectively bred teosinte, a wild grass, for desirable traits such as larger kernels and cobs. This early cultivation laid the foundation for the crop's remarkable journey across continents and through millennia. The transformation from wild grass to a productive crop involved changes in plant structure, including the development of a central stalk and the ability to support larger ears. These modifications not only increased yield but also made the crop easier to harvest, significantly impacting early agricultural societies. The spread of maize from its center of origin in Mexico was facilitated by human migration, trade routes, and cultural exchanges. By 4,000 years ago, maize had reached various parts of North and South America, including the southwestern United States, Peru, and Bolivia. This widespread adoption was driven by the crop's adaptability to different climatic and soil conditions, making it a versatile and resilient food source. Isotopic analysis of ancient human remains and carbon dating of maize artifacts have provided a chronological framework for understanding the dissemination and importance of maize in prehistoric diets and economies. Technological advancements in maize cultivation have been pivotal in its evolution as a key agricultural commodity. Early farmers developed sophisticated techniques such as crop rotation, intercropping, and the use of irrigation systems to enhance productivity and soil fertility. The integration of maize with other crops, particularly legumes, created sustainable agricultural systems that improved soil health and crop yields. The impact of these innovations is evident in the archaeological record, which shows increased agricultural productivity and the growth of complex societies reliant on maize. The introduction of maize to Europe and other parts of the world during the Columbian Exchange further underscores its global significance. European settlers adopted indigenous maize cultivation practices, adapting them to their own agricultural systems. The 20th century brought another wave of technological advancements, with the development of hybrid maize varieties and genetic modification techniques. These innovations have dramatically increased maize yields and resistance to pests and diseases, solidifying its role as a staple food crop and a key component of global food security. Environmental and climatic factors have also played a critical role in the evolution of maize agriculture.

Climatic events such as the Little Ice Age and prolonged droughts influenced the development and spread of maize varieties suited to different environmental conditions. Paleoenvironmental data and climate models have provided insights into how ancient farmers responded to these challenges by selecting and cultivating maize varieties that could withstand adverse conditions. The study of these adaptations offers valuable lessons for modern agriculture, particularly in the context of climate change and the need for resilient crop varieties. Today, maize is cultivated on a vast scale across the globe, serving as a primary food source, animal feed, and raw material for industrial products. However, modern maize agriculture faces several challenges, including the impacts of climate change, soil degradation, and the need for sustainable farming practices. Advances in biotechnology, precision agriculture, and the development of climate-resilient crop varieties are essential for addressing these challenges and ensuring the continued success of maize as a global staple.

### Objective of the study

The objective of this study is to analyze the temporal patterns in the evolution of maize agriculture from a geochronological perspective, synthesizing previous records, data, studies, reports, and scientific findings.

### Origins and early domestication

The origins and early domestication of maize are deeply rooted in the Balsas River Valley of southern Mexico, dating back over 9,000 years. This region is considered the cradle of maize agriculture, where indigenous peoples first began to selectively breed a wild grass known as teosinte (*Zea mays* ssp. *parviglumis*). The transformation from teosinte to domesticated maize (*Zea mays* ssp. *mays*) involved significant genetic, morphological, and agronomic changes that were driven by human selection for desirable traits. Archaeological excavations in the Balsas River Valley and surrounding areas have unearthed ancient maize cobs, phytoliths (silica bodies from plants), and pollen, providing concrete evidence of early maize cultivation. Some of the earliest maize cobs, dating to around 6,250 years ago, were discovered in Guilá Naquitz Cave in Oaxaca, Mexico. These cobs show clear signs of domestication, including larger and more numerous kernels compared to wild teosinte. Carbon dating and isotopic analysis of these findings have helped to establish a timeline for the domestication process. For instance, Piperno and Flannery (2001) provided crucial evidence that maize was being cultivated in the Balsas River Valley by around 9,000 years ago. This early maize was characterized by a combination of teosinte-like and domesticated traits, indicating a gradual transition from wild to cultivated forms. Genetic studies have played a crucial role in unraveling the domestication history of maize. By analyzing the DNA of modern maize varieties and comparing it with that of teosinte, researchers have identified specific genetic changes associated with domestication. Key genes involved in the development of kernel size, cob structure, and plant architecture were targets of selection by early farmers. One of the landmark studies in maize genetics was conducted by Matsuoka *et al.* (2002) <sup>[2]</sup>, which confirmed that all modern maize varieties can be traced back to a single domestication event in southern Mexico. This study used multilocus microsatellite genotyping to demonstrate the close genetic

relationship between maize and its wild ancestor, teosinte. The findings highlighted the role of human selection in driving the evolution of maize from a wild grass to a staple crop. The domestication of maize involved significant morphological changes that improved its utility as a food crop. Early farmers selected for traits such as larger kernels, more robust cobs, and a reduction in the hard casing around the seeds (glumes). These changes made maize easier to harvest and process, enhancing its value as a food source. The enlargement of kernels and cobs was particularly important, as it increased the caloric yield of the crop. Additionally, changes in plant architecture, such as the development of a single central stalk, facilitated denser planting and more efficient cultivation practices. These morphological adaptations were critical in transforming maize into a productive and reliable staple crop for ancient agricultural societies. Following its initial domestication, maize spread rapidly throughout the Americas, becoming a staple crop in various regions. By 4,000 years ago, maize had reached the southwestern United States, as well as parts of South America, including Peru and Bolivia. The crop's adaptability to different climatic and soil conditions facilitated its widespread adoption. Maize played a central role in the development of ancient civilizations, particularly in Mesoamerica. It was a primary food source and a key component of religious and cultural practices. The Maya, Aztec, and Inca civilizations, among others, relied heavily on maize for sustenance and incorporated it into their myths, rituals, and daily life. The significance of maize is evident in the archaeological record, where it appears in art, architecture, and even religious texts. The early domestication of maize was accompanied by the development of sophisticated agricultural practices. Early farmers developed techniques such as crop rotation, intercropping, and the use of terraces and irrigation to enhance productivity and sustainability. These practices improved soil fertility and crop yields, supporting the growth of complex societies. The integration of maize with other crops, particularly legumes, created sustainable agricultural systems that maintained soil health and maximized productivity. This period of innovation laid the groundwork for the extensive maize agriculture that would later spread across the Americas and eventually to other parts of the world.

### Spread and adaptation

Following its initial domestication in the Balsas River Valley of southern Mexico, maize rapidly spread across the Americas, adapting to a wide range of environments and becoming a staple crop for numerous indigenous cultures. By 4,000 years ago, maize had reached the southwestern United States, as well as various parts of South America, including Peru and Bolivia. This widespread dissemination was facilitated by human migration, trade networks, and cultural exchanges. Archaeological evidence, such as carbon-dated maize remains and isotopic analysis of ancient human bones, indicates that maize became a dietary staple in many regions, supporting the growth of complex societies.

Maize's adaptability to diverse climatic and soil conditions was a key factor in its successful spread. As maize moved out of its native tropical environment, it encountered different temperature regimes, altitudes, and precipitation patterns. Early farmers selected for traits that enhanced the

crop's resilience to these conditions, leading to the development of numerous landraces, locally adapted varieties with unique genetic and morphological characteristics. For example, in the highlands of Peru, maize adapted to grow at altitudes exceeding 3,000 meters, while in the lowland tropical forests, it developed tolerance to high humidity and poor soils. This adaptability was further enhanced by the genetic diversity inherent in maize, which allowed for continual selection and breeding of varieties suited to specific environments.

Maize played a central role in the development and sustenance of ancient civilizations throughout the Americas. In Mesoamerica, the Maya civilization relied heavily on maize, which was integral to their diet, economy, and religious practices. The Maya developed advanced agricultural techniques, such as raised fields and terracing, to maximize maize production in their challenging tropical environment. In the Andean region, the Inca civilization cultivated maize extensively, incorporating it into their agricultural terraces that covered the mountainous landscape. Maize was not only a food source but also used in the production of chicha, a traditional fermented beverage that held cultural and ceremonial significance. The Aztec civilization also placed great importance on maize, which was central to their agricultural and culinary practices. They developed chinampas artificial islands in lakes and wetlands that allowed for intensive maize cultivation. Maize was considered a gift from the gods, and its cultivation was intertwined with religious ceremonies and offerings.

The spread and adaptation of maize were accompanied by significant agricultural innovations that enhanced its productivity and sustainability. Indigenous farmers developed crop rotation systems, intercropping, and the use of organic fertilizers to maintain soil fertility and reduce pest pressures. These practices were particularly important in regions with poor soils or challenging climatic conditions. In Mesoamerica, the milpa system an ancient form of polyculture involved the simultaneous cultivation of maize, beans, and squash. This system provided multiple benefits: maize provided a structure for beans to climb, beans fixed nitrogen in the soil, and squash provided ground cover to suppress weeds and retain moisture. Such integrated farming practices improved overall yield and sustainability. Archaeological findings, including ancient storage pits, agricultural tools, and remnants of maize cobs, provide concrete evidence of the widespread cultivation of maize across different regions. Genetic studies have also revealed the complex history of maize adaptation, showing how different varieties were selected and bred for specific environments. These studies highlight the role of human agency in shaping the genetic diversity of maize.

### **Environmental and climatic influences**

The evolution of maize agriculture has been profoundly influenced by technological advancements and environmental and climatic factors. Together, these elements have shaped the cultivation practices, productivity, and resilience of maize across different periods and regions. Technological advancements in maize agriculture have been instrumental in improving yields and sustainability. Early indigenous farmers developed innovative techniques such as crop rotation systems, intercropping with legumes, and the use of terraces and irrigation. Crop rotation helped maintain soil fertility by alternating maize with nitrogen-fixing crops

like beans, which replenished essential nutrients in the soil. Intercropping, particularly the milpa system involving maize, beans, and squash, created symbiotic relationships between plants, enhancing overall productivity and soil health. The use of terraces in hilly or mountainous regions prevented soil erosion and optimized water use, while irrigation systems ensured consistent water supply, crucial for maize cultivation in arid and semi-arid areas. During the early colonial period, European settlers encountered these advanced indigenous agricultural practices and incorporated them into their own farming systems. They adapted and modified these techniques, integrating them with Old World agricultural methods. For instance, they adopted the practice of intercropping and crop rotation but introduced new crops and livestock, creating diverse agricultural landscapes that benefited from the strengths of both New World and Old-World practices.

The 20th century marked a significant era of technological innovation in maize agriculture with the advent of modern breeding techniques. Hybridization emerged as a key development, leading to the production of hybrid maize varieties with superior traits such as higher yields, uniformity, and disease resistance. The introduction of hybrid maize revolutionized agriculture, as these varieties were more productive and resilient than traditional open-pollinated varieties. Genetic modification further enhanced maize agriculture, allowing for the development of genetically engineered maize with traits such as pest resistance, herbicide tolerance, and improved nutritional content. These advancements have significantly boosted maize productivity and have been critical in addressing challenges related to food security and agricultural sustainability.

Environmental and climatic factors have also played a pivotal role in shaping the evolution of maize agriculture. Climatic events such as the Little Ice Age, which occurred between the 14th and 19th centuries, brought cooler temperatures and shorter growing seasons, affecting maize cultivation. Prolonged droughts and changes in precipitation patterns have historically influenced maize yields, prompting farmers to develop adaptive strategies. Soil composition, temperature, and precipitation patterns determine the suitability of different regions for maize agriculture, influencing the selection of maize varieties and cultivation practices.

Paleoenvironmental data and climate models have provided valuable insights into how ancient farmers adapted their practices to changing environmental conditions. For example, during periods of climatic instability, ancient farmers might have selected drought-tolerant maize varieties or implemented water conservation techniques to sustain their crops. Studies of ancient pollen records, sediment cores, and other paleoenvironmental indicators have helped reconstruct historical climate conditions and their impact on maize agriculture.

In modern times, climate change continues to pose significant challenges to maize agriculture. Rising temperatures, altered precipitation patterns, and increased frequency of extreme weather events threaten maize productivity. Research and development efforts are focused on breeding climate-resilient maize varieties that can withstand heat, drought, and other stressors. Additionally, precision agriculture technologies, such as remote sensing and data analytics, are being utilized to optimize water use,

monitor crop health, and enhance overall farm management. In summary, the evolution of maize agriculture has been profoundly shaped by technological advancements and environmental and climatic influences. From early innovations in crop rotation and intercropping to modern genetic modification and climate-resilient breeding, technological progress has continually improved maize productivity and sustainability. Concurrently, environmental and climatic factors have driven adaptive strategies and innovations, ensuring the resilience of maize agriculture through changing conditions. Understanding the interplay between technology and environment is crucial for developing sustainable agricultural practices and addressing future challenges in maize cultivation.

### Conclusion

The study of the evolution of maize agriculture reveals a remarkable journey of adaptation, innovation, and resilience spanning over 9,000 years. Originating in the Balsas River Valley of southern Mexico, maize has transformed from a wild grass into one of the world's most important staple crops, thanks to significant genetic, morphological, and agronomic changes. Technological advancements, from early crop rotation and intercropping practices to modern hybridization and genetic modification, have continually improved maize productivity and sustainability. Environmental and climatic factors have shaped maize agriculture, necessitating adaptive strategies to cope with challenges such as climate variability and soil conditions. The interplay between technological innovation and environmental adaptation has ensured the resilience and success of maize cultivation across diverse regions and historical periods. Understanding these temporal patterns provides valuable insights into the development of sustainable agricultural practices and informs future efforts to enhance maize productivity and food security in the face of global environmental changes.

### References

1. Piperno DR, Flannery KV. The earliest archaeological maize (*Zea mays* L.) from highland Mexico: new accelerator mass spectrometry dates and their implications. *Proc. Natl. Acad. Sci. USA.* 2001;98(4):2101-2103.
2. Matsuoka Y, Vigouroux Y, Goodman MM, Sanchez GJ, Buckler E, Doebley J, *et al.* A single domestication for maize shown by multilocus microsatellite genotyping. *Proc. Natl. Acad. Sci. USA.* 2002;99(9):6080-6084.
3. Staller JE, Tykot RH, Benz BF. *Histories of maize in Mesoamerica: Multidisciplinary approaches.* Walnut Creek (CA): Left Coast Press; c2006.
4. Pohl ME, Piperno DR, Pope KO, Jones JG. Microfossil evidence for pre-Columbian maize dispersals in the neotropics from San Andrés, Tabasco, Mexico. *Proc Natl Acad Sci USA.* 2007;104(16):6870-6875.
5. Doebley JF, Gaut BS, Smith BD. The molecular genetics of crop domestication. *Cell.* 2006;127(7):1309-1321.
6. van Heerwaarden J, Hellin J, Visser RF, Etten JV. Maize landraces and adaptation to climate change in Mexico. *J Crop Improv.* 2009;23(4):395-411.
7. Smith BD. *The Emergence of Agriculture.* New York: Scientific American Library; c1995.

8. Benz BF. Archaeological evidence of teosinte domestication from Guilá Naquitz, Oaxaca. *Proc Natl Acad Sci USA.* 2001;98(4):2104-2106.
9. Harlan JR. *Crops and Man.* 2<sup>nd</sup> ed. Madison (WI): American Society of Agronomy; c1992.
10. Pressoir G, Berthaud J. Population structure and strong divergent selection shape phenotypic diversification in maize landraces. *Heredity.* 2004;92(2):95-101.