FAPC-194

Robert M. Kerr Food & Agricultural Products Center

FOOD TECHNOLOGY FACT SHEET

Adding Value to OKLAHOMA

405-744-6071 • www.fapc.biz • fapc@okstate.edu

Growing North American Indigenous Corn

Phillip J. Long
Interdisciplinary Science Graduate Student

Andrew N. Doust
Botony Associate Professor

Rodney Holcomb
FAPC Agricultural Economist

Domestication/History

Corn (*Zea mays*), also known as maize, is a major worldwide grain crop. Modern maize has been developed from the large diversity of landraces that were grown by indigenous groups. All of these landraces can be genetically traced back to the domestication of maize in southern Mexico around 9,000 years ago (Van Heerwaardena, et al. 2011). After domestication, indigenous peoples began to breed maize to suit their needs and trade with their neighbors. Maize continued to spread north and south across the Americas, while developing a broad range of traits (Vigouroux, et al. 2008). A widespread form of intercropping used corn, beans and squash planted together (known as the "three sisters") was widely adopted by many Native Americans. While this practice was widespread, it was not ubiquitous, as some tribes included other species or omitted one of the "three sisters" (Scarry 2008). Some tribes also grew maize by planting in mounds on river floodplains without any clear record of intercropping. Since maize requires a lot of nutrients, rotting fish and other organic fertilizers were often used (Gonella 2007). Once Europeans arrived in the Western Hemisphere, they began to breed landraces together to suit their preferences. The varieties that were established before the rise of modern hybrids are now considered heirloom varieties. There is rising interest amongst home gardeners and farmers-market producers to grow landraces and recent heirloom varieties. The information in this report is to aid those who are interested in growing indigenous maize or landrace maize.

Maize Kernel Types

The maize cob consists of many rows of kernels; each one develops from a fertilized flower. Each kernel consists of a seed containing starchy endosperm and the embryo, surrounded by a seed coat that is fused to the fruit wall (pericarp). The pericarp and seed coat protect the seed from pests and the environment, and the endosperm provides nutrition to the embryo upon germination. Differences in the endosperm and pericarp define five categories of kernels that many landraces and heirlooms fall into: popcorn, flint, flour, dent and sweet.

Popcorn: Likely one of the oldest forms to arise after domestication, characterized by a thick pericarp and dense endosperm. Primarily used for popping.

Flint: Similar to a popcorn, but larger in size. Consists of a thick pericarp and a hard endosperm that in some cases appears translucent or glassy. Used in a broad range of applications (hominy, corn flour, roasted, etc.)

Flour: A very popular category in North America. This category can be identified by a very thin pericarp and a soft endosperm comprised of fine-grained starch. Flour corn was used in the same way as flint corns, but offered easier processing and finer flour.

Dent: Characterized by the presence of a dimple, or dent, on the rounded end of a kernel. This is caused by a hard, flinty endosperm on the sides and a soft center. As the kernel dries during maturation, the softer center shrinks causing a "dent." Most modern maize varieties are hybrids of dent and flints.

Sweet: Possess reduced ability to convert sugar in the endosperm into starch, causing their sweet flavor. Since they have a reduced amount of starch at maturity, the kernels shrink and become very wrinkled.

Growing Indigenous/Heirloom Maize

Indigenous and Heirloom maize require the same basic care as common garden varieties; however, they may be more specific in their requirements as each race was adapted to its

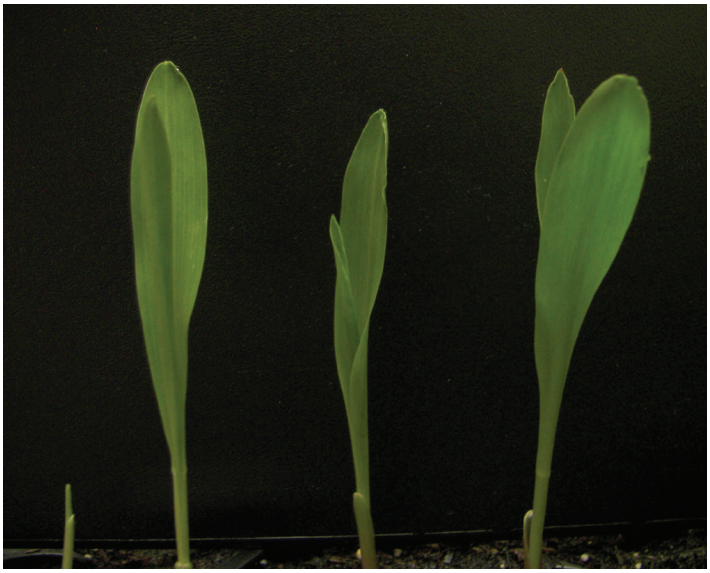

Figure 1. Corn seedlings.

local environment over many centuries. For general planting recommendations for sweet corn, read the Sweet Corn Extension sheet from Iowa State University (Haynes, Everhart and Juaron 2002). Since the landraces were developed across the entire range of maize production (Argentina to Canada) and in varying environments, there are many growing variables to consider. These include water requirements, length of growing season and temperature. Some landraces, particularly those from more tropical areas, have strict requirements for day length and will not flower in the longer days of higher latitudes. It is worthwhile to discover where the landrace was developed and how it was cultivated by the indigenous groups from that place. While it is possible to grow landraces under different conditions, it is best to choose types of corn that originate from a similar climate and latitude.

Environmental Considerations Climate

Landraces from more arid environments are more drought tolerant, but are also likely to be more prone to root rot when overwatered. Generally, maize does well with lots of sun, but if the temperatures get too high, landraces from northern latitudes and coastal areas may become over-stressed.

Growing Season

The length of a growing season is often measured by the number of frost-free days. Maize landraces exhibit a range of growing season length requirements. Gaspe Flint require 45-60 days from planting to harvest and comes from Northern Maine and Southeast Canada. Many landraces from Mexico require well more than 100 days before harvest. To find out how long your growing season is, go to Dave's Garden website and enter your zip code (http://davesgarden.com/guides/freeze-frost-dates/#b).

Photoperiod

Photoperiod is the length of time an organism is exposed to light and darkness. Many plants are triggered to flower by the length of darkness they experience every night (photoperiod sensitivity). The higher the latitude, the longer days in summer become (shorter nights). Maize originating from nearer to the equator needs long nights and will not flower when grown too far north. As maize agriculture spread north, it adapted to its new growing conditions and lost this sensitivity to the length of each night. This allowed maize to be bred to flower earlier, fitting into the shorter growing seasons of the northern latitudes (Vigouroux, et al. 2008).

Planting/Growing Considerations

Modern maize hybrids have been bred for increased hardiness to a broad range of environmental stresses. Landraces with a specific desirable trait have been used in breeding programs to produce varieties with a combination of those traits. This allows newer varieties to display the best qualities that were previously spread across large numbers of landraces.

Insects, fungi and viruses are biological stressors that need to be eradicated when present. Landraces and Heirlooms can be resistant to a specific infestation or infection; however, many landraces can be very susceptible to biological stressors.

Lodging (falling–over) is a major issue for landraces and is partially a result of lower planting densities. Many indigenous peoples mounded fertilized soil around the base of each plant a few months after planting to increase root growth. The additional roots provide structural support to combat lodging and increase nutrient uptake.

Landraces and heirlooms will need soil that is high in available nitrogen. It is best to prepare the soil before planting. Indigenous fertilization practices using buried fish and/or intercropping can be used, but are not necessary.

Some landraces produce many tillers (aka "suckers"), which are lateral branches that originate at ground level. If this is the case, early removal is often required to maximize yield.

How to Learn about your Landrace or Heirloom Variety

If you know the people group (tribe) associated with the landrace you wish to grow or know the common name for your heirloom, you can likely find it in the U.S. Department of Agriculture Agricultural Research Services' Germplasm Resources Information Network (GRIN). This database hosts a large number of Native American maize landraces and provides a large amount of information in each landrace's profile (http://www.ars-grin.gov/).

To search the GRIN database, use these instructions:

1) Follow the link and type "Zea mays" in the search bar, including 1-2 keywords from the name of the landrace of your interest. The profile page gives some general information and can be a good source of information about where the landrace was originally grown and its tribal affiliations.
2) Click on the "Observations" link to see detailed trait information. The observations page is where you can often find kernel and ear dimensions, colors, average ear production, days to silk and kernel weight. The amount and type of data recorded for each landrace varies widely.

If your landrace is from a Native American tribe, their tribal governments frequently have information about how to care for their corn. When approaching tribes for information, recognize that many of their traditions are based on culture and ceremonies, so they may not wish to share all of their information.

Managing Seed Stocks & Genetics

When growing an indigenous landrace or heirloom, it is most common for the grower to save "seed corn" to plant the next year. In effect the grower maintains a small seed bank to meet their personal needs. This practice essentially requires that the grower manage a small-scale breeding program, where desirable traits are selected for future planting, cross-pollination with other varieties is minimized and inbreeding depression is minimized.

Avoiding Crosspollination with Other Varieties

The maize cob is usually fertilized with pollen from surrounding plants, but pollination from other maize varieties may introduce new traits that differ from the original landrace. This is undesirable unless you wish to do breeding experiments. Even then, results may be counter-intuitive. For example, attempting to interbreed different types of sweet corn may result in corn that is less sweet than either parent because of the complex genetics of this trait. Modern sweet corn varieties usually incorporate multi-generational crosses to manipulate sweetness and other traits (Azanza, Bar-Zur and Juvik 1996).

In order to avoid crosspollination with other varieties, it is best to grow your corn away from any other type of corn. The distance required varies due to several factors. If a commercial field of corn is planted nearby, it is best to be around 1 mile away. Wind is a large factor, as corn pollen is not viable very long once airborne. If your garden or field is sheltered from wind, distances can be reduced. A more effective method is to stagger planting dates so that pollination times are separated. This can be done using "Days to Silk" (when silks emerge on ears), when tassels emerge or anthesis occurs (pollen release). These 3 events all occur at different stages of growth, and the actual number of days you will observe will vary from the average due to environmental growth conditions. The number of days to silk emergence for most landraces and heirlooms can be found under its GRIN profile (USDA GRIN 2013). In extreme cases, hand pollination may be required. It is much more labor intensive, but very effective. The Maize Genomics Database has detailed resources on how to hand pollinate corn (http://www.maizegdb.org/IMP/WEB/pollen.htm).

Trait Selection

It is best to have a thorough understanding of the traits your landrace exhibits and to preserve the ears that resemble the original traits (easily found on GRIN). The best traits to keep an eye on are kernel color, kernel type, number of rows around an ear, ear length, texture of endosperm and days to silk/ripening. Common traits that can be a sign of crosspollination from other varieties are change in kernel type (i.e. flour to dent), increase in rows of kernels, color changes (plant and kernel) and plant dimensions. Traits from crosspollination normally don't present themselves until the following year (except kernel endosperm and embryo), so keep in mind most selection at harvest is eliminating the previous year's crosspollination. Actively selecting for the desired traits will minimize the flow of unwanted genes into your seed bank population. In addition to separating your harvest into ears exhibiting wanted and unwanted traits, it is natural to select healthy-looking ears that have performed well in your field/garden for your seed stocks.

Figure 2. Miami white corn kernels.

Maintaining Genetic Diversity

Inbreeding depression in corn is a phenomenon where plant health and production decrease as genetic diversity decreases. When a population is too small and/or selection is too stringent, genetic differences are reduced. When population sizes are large enough or multiple sources of seed are grown together, it will result in more vigorous plants and increase yield. Garden plot-size populations can have stable and healthy levels of genetic diversity. A larger population size will increase your ability to maintain the traits you want to preserve (Guzman and Lamkey 2000). When populations are small (less than 30 plants at harvest), trait selection should be less stringent; otherwise, the plants can lose their vigor and yield. Desired genetic traits could also be lost with the rejected seed when population sizes are low (Solomon, Martin and Zeppa 2010).

Seed-saving Practices

When storing seeds from year-to-year, it is best to store kernels on the ear with husks pulled back or removed to help regulate moisture and increase seed viability. Cool and dry storage conditions are best to prevent mold and rotting. For optimum long-term viability, store the seed at 41 degrees Fahrenheit and 25 percent RH for two weeks, before placing in an air-tightcontainer at 0 degrees Fahrenheit (Walter and Roos 1998). A more practical approach is to allow the seeds to dry in an air conditioned room for two weeks and store in a standard freezer. Germination rates can be kept higher, reducing losses by planting the oldest seed each year. The longer kernels remain in storage, the less viable they will become.

References

Azanza, Fermin, Avri Bar-Zur, and John A. Juvik. "Variation in sweet corn kernel characteristics assosciated with stand establishment and eating quality." Euphytica (Klewer Academic Publishers), no. 87 (1996): 7-18.

Gonella, Michael P. "Myaamia Ethnobotany." Electronic Thesis or Dissertation, 2007.

Guzman, Peter S, and Kendall R Lamkey. "Effective Population Size and Genetic Variability in the BS11 Maize Population." Crop Science 40 (2000): 338-346.

Haynes, Cindy, Eldon Everhart, and Richard Juaron. Sweet Corn. Extension Report, Iowa State University Extension, Iowa State University, Ames, IA: Iowa State Cooperative Extension Service, 2002.

Scarry, C. Margaret. "Crop Husbandry Practices in North America's Eastern Woodlands." In Case Studies in Environmental Archaeology: Interdiscpilinary Contributions to Archaeology, by Elizabeth J. Reitz, Sylvia J. Scudder and C. Margaret Scarry, 391-404. New York: Springer New York, 2008.

Solomon, K F, I Martin, and A Zeppa. "Temporal genetic structure patterns in tropical maize populations under reciprocal recurrent selection." Euphytica 176 (2010): 239-249.

USDA GRIN. Ames 24975 Miami White Flour. 12 2, 2013. http://www.ars-grin.gov/cgi-bin/npgs/acc/display.pl?1569643 (accessed 12 2, 2013).

Van Heerwaardena, Joost, et al. "A second look at the cradle of maize cultivation." Proceedings of the National Academy of Sciences 108, no. 3 (2011): 1088-1092.

Vigouroux, Yves, Jeffery C Glaubitz, Yoshihiro Matsuoka, Jose J Sanchez Gonzales, and John Doebley . "Population Structure And Genetic Diversity Of New World Maize Races Assessed By DNA Microsatellites ." American Journal of Botany 95, no. 10 (2008): 1240–1253.

Walters, Christina T, and Eric E. Roos. “Saving Seeds for the Long Term” Agricultural Research Magazine Vol 46-9 (1998).

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Director of Oklahoma Cooperative Extension Service, Oklahoma State University, Stillwater, Oklahoma. This publication is printed and issued by Oklahoma State University as authorized by the Vice President, Dean, and Director of the Division of Agricultural Sciences and Natural Resources and has been prepared and distributed at a cost of 74 cents per copy. 0615 MG