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Hybrid Seed Production in Maize

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This module describes some of the background and history of corn (*Zea mays*), as well as the key agronomic practices involved in hybrid corn seed production. The module also highlights specific aspects of sweet corn production.

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Selection of corn traits has occurred for thousands of years.

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Cultivated maize experienced a rapid conversion in the U.S. from open-pollinated varieties to hybrids in the 1930's and 1940's.

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Hybrid seed technologies have expanded throughout the world, with 'winter seed' nurseries and seed production acreage alternating growing seasons from the southern and northern hemispheres.

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Average maize (corn) yields have increased dramatically with the increasing use of hybrids.

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Worldwide demand for corn continues to grow, as grain for ethanol production is now expanding in North America.

Slide 8

Understanding the crop development stages of corn is important for grain and seed production.

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Early, vigorous growth in a favorable environment is important for eventual seed yields and quality.

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Brace root formation also occurs at the end of the vegetative period. Brace roots are important for plant support and nutrient absorption.

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Corn is a monoecious plant, and proper management of the crop's reproductive phase is critical for successful seed production.

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Most early reproductive stages of corn growth are not visible to the eye.

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Ear initials ear shoots, tassel emergence and silk elongation are stages (VT-R1) when the corn plant is most vulnerable to hail damage.

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The pollen shed period typically extends for 1-2 weeks. Each individual silk must emerge for pollination, fertilization and kernel development to occur.

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Silk clipping

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Most of the R3 kernels (shown here) have now grown out from the surrounding cob, and the silks are brown and becoming dry.

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Final yield depends on (1) the number of kernels that develop, and (2) the final size or weight of the kernels.

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Seed development pictures

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The average kernel moisture content at R6 (black layer formation) is 30-35%, but can vary considerably between hybrids and environmental conditions.

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Seed company R/D staff often state that seed size effects are small compared to (1) crop genetics, (2) insect resistance, and (3) seed treatment effects on crop establishment and eventual yield.

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This diagram illustrates the typical screen size pattern used to divide a bulk seedlot into sized seedlots of large, medium, and small rounds and flats.

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Many other corn types are common around the world.

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Dent corn is the dominant kernel and endosperm type grown.

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Flint and flour corn types are also economically important.

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Sweet corn (to be discussed in more detail at the end of this module) and popcorn also have regional importance.

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The seed coat, endosperm and embryo are the major components of a maize seed.

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The pericarp is an important protective structure.

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The embryo (or germ) is rich in protein and oil.

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The black layer forms late in seed development at the base of the embryo.

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This figure shows key differences in fractions of starches, proteins and oil by seed part.

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Corn seed production relies on a thorough understanding of crop growth and development.

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Controlling corn pollen drift/movement has always been a major management concern in commercial hybrid and specialty corn seed production.

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Nicking and field selection can assist in isolation management.

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Maize pollen grains are among the heaviest and largest (~90-100 μm in diameter) of the various wind-dispersed pollen grains found in plants, thus limiting to some extent the distance corn pollen can travel.

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Pollen shed can begin before tassels have completely emerged from the whorl, and can continue over a week or longer.

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Producers of Identity Preserved (IP) non-GMO (genetically modified organisms) corn, such as high oil lines, etc., also need to minimize pollen contamination of their crop by GMO corn.

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Isolation strategies require close coordination of planting operations with neighboring farmers.

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Research indicates that cross-pollination in corn is limited to 1% or less on a whole field basis by a separation distance of 660 feet, and to 0.5% or less by a distance of 1,000 feet.

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Many soil tillage options exist for corn seed production acreage.

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Seed company reps will adjust tillage recommendations based on local factors.

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Planting decisions (populations, seeding depth, etc.) are also coordinated between company agronomists and contract growers.

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Field corn seeding using split dates is commonly employed to achieve proper nicking.

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Several other practices can also be employed to ensure abundant pollen at silking.

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Cool temperatures at planting generally restrict nutrient uptake (especially P-phosphorus) from the soil.

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Corn is a relatively heavy feeder, requiring substantial levels of available soil nutrients.

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Successful hybrid seed corn production also relies on excellent weed and pest management.

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Corn disease and insect pressure can be substantial depending on location and environmental conditions.

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Manual or mechanical removal of tassels must be done in the 7-10d window when tassels are ready to emerge and actual pollination begins. Yield reductions of up to 10% are common with detasseling.

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Mechanical detasseling

Slide 51

Manual detasseling

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CMS (cytoplasmic male sterility) incorporates specific genes into inbred parents that make pollen either sterile, or delay pollen shed until after silking of the female parent. Incorporation of this trait narrows the crop's genetic base, making it more susceptible to diseases (e.g. gray leaf spot).

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Other possible techniques to manage maize flowering continue to be studied.

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Harvesting occurs once corn seed has attained maximum dry weight and the black abscission layer (R6) has formed. Average kernel moisture at R6 is 30-35%, but can vary between hybrids and environmental conditions.

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The corn husks and most leaves are no longer green at this point, although the stalk may be.

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Seed drying is a critical aspect of production and eventual seed quality.

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Air temps and drying rates can be adjusted as needed for certain hybrids or harvest conditions.

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Corn seed storage durations are related to seed moisture content levels.

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Seed moisture levels below 10% have drawbacks.

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Seed conditioning takes kernels from the ears and readies them for eventual packaging and planting.

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Numerous steps are employed in the scalping, sizing and seed treatment operations.

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Seed corn units (by weight or kernel count) are now commonly marketed.

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Seed quality testing is conducted throughout the harvest, conditioning and storage phases of corn seed production.

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Inbred line development and maintenance is a critical part of the maize genetic base.

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Hybrid vigor is the basis for modern corn seed germplasm and crop advances.

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Double-cross hybrids were an important first step beyond open-pollinated varieties.

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Double-cross hybrids were commonly grown in the 1950's through the 1970's in major production regions around the world.

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The broader genetic base of double-cross hybrids (DCH's) has some advantages when various crop stresses occur.

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Lower seed costs are also associated with DCH's.

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DCH's also have several drawbacks.

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Since the 1980's, single-cross hybrids (SCH's) have become dominant in the industry.

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Several key traits are associated with SCH's.

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SCH's have led to an explosion of hybrids, and field/environment testing programs.

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Three-way hybrids fill a middle-ground between DCH's and SCH's.

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3-way hybrids are frequently used in popcorn and sweet corn breeding programs.

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Sweet corn seed is typically smaller and less seedlings are vigorous than those of field corn hybrids.

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High sugar endosperm mutants of sweet corn (e.g. se, sh₂, others) present special challenges at seed harvest as well.

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Conditioning protocols for sweet corn seed are substantially different than those discussed for field corn.

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Modifications are needed to handle the smaller, lighter sweet corn kernels.

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Seed conditioning steps are clearly linked to eventual seed quality and seedling establishment.

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Sweet corn is a weaker performer throughout seedling growth compared to field corn. Once the crop is established, however, its growth and development is quite acceptable.

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A summary of hybrid and inbred line definitions.

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A summary of single-cross, 3-way, and multiple-cross hybrids.

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A summary of synthetics, blends and OP varieties.

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Appreciation is extended to the resources and individuals listed below.

