



Organic Seed Alliance

*Advancing the ethical development and stewardship
of the genetic resources of agricultural seed*

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How to Breed Sweet Corn for Organic Agriculture



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I. Introduction

Sweet corn is a type of corn or maize (*Zea mays*) distinguished by one or more mutations that increase sugar or polysaccharide content in the **kernels***. Sweet corn has traits that make it both easy and challenging to breed. For example, in general corn is easy to both cross- and self-pollinate, providing flexibility in breeding. On the other hand, certain challenges arise because sweet corn flavor, tenderness, and other ear-related traits need to be evaluated after pollination has occurred. This manual will help you understand these traits, among others, and teach you the most effective ways to improve sweet corn for your organic farm.

Sweet corn varieties can be classified by their intended end-use. Sweet corn is grown for a number of end-uses, including fresh market, canned, frozen, dehydrated, and creamed corn. This manual will focus on breeding for fresh market uses. Sweet corn varieties are also classified based on the type of **endosperm** mutation that causes increased sweetness. In North America, the most common types of sweet corn are: **sugary**, based on the presence of the *su1* allele; **sugary enhancer**, based on the presence of both *su1* and *se* alleles; and **supersweet**, based on the presence of the *sh2* allele. In more tropical areas, such as Hawaii, the brittle1 or *bt1* allele is also commonly seen. All of these genes will be discussed in more detail in the **Selection techniques** section.

II. Introduction to Breeding

As you begin making your sweet corn breeding plans, we encourage you to refer to OSA's *Introduction to On-Farm Organic Plant Breeding* for an in-depth explanation and discussion of the fundamental concepts of plant breeding. Reading this publication will further aid you in your breeding work. In brief, the steps involved in breeding include:

1. Developing and defining your breeding goals
2. Identifying parental material, including conducting trials to find the best parents
3. Making crosses
4. Selecting and recombining your selections

III. Breeding Goals

The first step in any breeding project is to identify the goals of the project. Below are some traits that can be important in sweet corn breeding projects. A discussion of selection techniques for these traits can be found in the **Selection** section. The list below is long. No one breeding project will include all of these traits. Use this list as a brainstorming tool and aim to work on 4 to 6 traits at most.

<i>Plant/Agronomic Traits:</i>	
	Germination
	Early vigor
	Silk date
	Tassel date
	Plant height
	Ear height
	Anther color
<i>Defensive Traits:</i>	
	Disease resistance (including Smut, Rust, Northern Corn Leaf Blight, Southern Corn Leaf Blight, Maize Dwarf Mosaic Virus, Stewart's Wilt, Stalk Rot, Ear Rot, Kernel Rot)

*Definitions for technical words that are italicized and bolded can be found in the glossary

	Pest resistance (Corn Earworm, European Corn Bore)
	Drought tolerance
	Lodging resistance
<i>Ear Traits:</i>	
	Silk color
	Row number
	Tip fill
	Row straightness
	Ear shape
	Ear size
	Husk appearance
	Husk protection
	Ear leaf length
	Ease of ear detachment
	Ease of husking
	Kernel color
<i>Quality:</i>	
	Sweetness
	Flavor
	Tenderness
	Kernel depth

IV. Germplasm

In general, when breeding sweet corn, you will work within one of the main endosperm mutant types: *su1* (sugary), *su1* and *se* combined (sugary enhancer), or *sh2* (supersweet). *Su1* and *sh2* are recessive alleles, meaning their effects will only be noticeable if two copies of the allele are present (refer to OSA's *Introduction to On-Farm Organic Plant Breeding* for more on recessive and dominant alleles).

Much of the breeding efforts in sweet corn are relatively recent. Up until the 1960s, all commercial sweet corn was based on the *su1* sugary mutation, which, relative to supersweet and sugary enhanced corn, produced relatively less sugar. In addition, the sugar produced by sugary varieties is rapidly converted to starch after harvest, causing very limited shelf life. Whereas it is possible to find many older

sugary open-pollinated varieties, almost all super-sweet and sugary enhanced types of sweet corn are **hybrid** varieties.

Sources for germplasm include commercial seed companies, public breeding programs, and the National Plant Germplasm System. Some of the principal sweet corn breeding companies include Illinois Foundation Seed, Crookham Company, Sakata, Harris Moran, Mesa Maize, and Seminis. Some of the key public programs can be found at University of Wisconsin, Oregon State University, Cornell, and University of Hawaii. When you source material, be sure to thoroughly investigate all intellectual property claims.

Because sweet corn is the same species (*Zea mays*) as other corn types, such as dent, flint, flour (all commonly referred to as field corn), and popcorn, crosses can be made between sweet corn and any

of these types. However, when making crosses between sweet corn and other types of corn, keep in mind that quality traits such as sweetness, flavor, and tenderness are complex and very difficult to maintain or recover if all of the parents are not high-quality. The University of Wisconsin sweet corn program has developed some material that derives from crosses between temperate and tropical field corn and may be useful as parental material when breeding for certain traits, including plant height, vigor, and disease and pest resistance. Some of this material can be obtained from the USDA-GRIN system by searching for “sweet corn Tracy.”

V. Reproductive Biology and Pollination Techniques

Corn is a monoecious plant: The **tassels** represent the male (pollen-bearing) inflorescences and the ears represent the female (seed-bearing) inflorescences. Corn is primarily cross-pollinated by wind. Cross-pollination is encouraged by two factors. First, the tassels are physically separated from the ears. Second, **anthesis**, also known as tasseling or pollen shed, generally begins before the **silks** emerge; although, modern varieties may have simultaneous anthesis and **silking**. It takes between two to seven days to shed all of the pollen, with shedding beginning near the top and progressing down the tassel. Silks take two to six days to fully emerge. Each individual silk, when pollinated, forms a single kernel on the ear. Although cross-pollination is by far the primary mode of pollination under natural conditions, corn is self-compatible and self-pollinations are relatively easy to make.

Because the endosperm is the bulk of what we see and eat when we consume sweet corn, sweet corn breeders must work with an unusual genetic effect called **xenia**. Xenia refers to observable effects that occur due to the influence of pollen. In sweet corn, the two most important traits affected by pollen are kernel color and sweetness. For example, yellow kernel color is dominant to white, and if a white variety receives pollen from a yellow variety, yellow kernels will appear among the white ones.

For the purposes of plant breeding, corn pollination can be done in three ways: open, uncontrolled

pollination, controlled pollination by **detasseling**, and controlled hand pollination.

Open pollination: Open pollination is straightforward and done by planting the plants you want to cross-pollinate in close enough proximity to reliably cross, typically separated by no more than 10 feet (3 meters). If you are working with varieties of differing relative maturities you may need to stagger planting times to ensure that all of the plants are simultaneously releasing and receptive to pollen.

Detasseling: Controlled pollination by detasseling is a relatively simple method to make many simultaneous crosses. Plant the female or intended pollen recipient next to the male pollen donor or donors. Remove tassels on the female as soon as they begin to emerge, checking regularly to make sure that all of the tassels are removed.



To detassel corn, grab the tassel just above the topmost leaf. Bend the tassel slightly and firmly pull up to break the tassel off the plant. *Photo credit: Long Island Seed Project*

Hand Pollination: For hand pollinations, you will need special bags to cover the ears and the tassels. Both can be ordered from Lawson bag company, with **shoot bags** for sweet corn sold as #217 and **tassel bags** sold as #402 or #404, depending on the size.



Sweet corn breeding supplies, including a pollinating apron holding Lawson tassel and shoot bags, Bostich stapling pliers, paper clips, pocket knife, spare staples, and a water bottle.

First, cover the ear **shoots** as they emerge, but before the silks emerge. Shoots will first appear as a bulge along the nodes of the stem, and can appear with or without shoot leaves.



The goal will be to place a shoot bag on the top-most ear shoot. Trim the shoot leaves so that the bag will fit firmly over the shoot, with the longer side of the bag between the shoot and the stem. This protects the shoots from unintended pollination. Check the shoot bags regularly to make sure they have not fallen off.



Within a few days to few weeks of putting on the first shoot bags, it will be time for the next step in the process: **setting up** pollinations. Look for plants that have some **anthers** open and shedding pollen, have some anthers that are still not open, and have silks that have emerged. Sometimes you may not be able to see silk emerging from a shoot, but if you cut it back (see following images), there may be silks that are close to emerging. Once a plant matching the above criteria is identified, cut back the silks to create a brush of silks sticking up. These silks will be used for pollination the following day. To cut back the shoot for pollination, use a knife to cut across the shoot, parallel to the ground, and an inch or two from the top. Cut deep enough to expose a pencil-width area of silks. Do not cut so far that you nick the developing ear. Replace the

shoot bag after cutting the shoot back, folding the top of the bag down to indicate that this plant is ready to pollinate tomorrow.



After you cut the shoots, the next step is preparing the tassels. Find tassels that are shedding pollen but still have some unopened anthers and then slip on a tassel bag, pulling it down snugly and past the top leaf. Smooth out the bag and fold a corner of the bottom of the bag up at an angle, so the opening at the bottom is sealed against the stem. Secure the tassel bag with a #1 non-skid standard paper clip. To use corn breeding terminology, you have now “set up” a tassel bag that can be “**taken down**” the next day.



Take down the tassel bags the next day, once the bags are dry and pollen is shedding. Shake fresh pollen into the tassel bag by holding the tassel and bag perpendicular to the ground with one hand and striking the bag firmly against your other hand. To avoid losing pollen, hold the bag sideways, remove it from the tassel, and fold it in half. With the bag still folded, open the front, creating a pouch. Place this pouch over the shoot to be pollinated. Moving quickly, take off the shoot bag, slide the tassel bag over the shoot and unfold the bag. Make sure not to touch the silks with your hands because your hands are likely contaminated with pollen from the field. Shake the tassel bag to dislodge any pollen remaining in the bag. You have now made a controlled pollination. Wrap the tassel bag around the stem and staple the bag in place, leaving enough room for an ear to grow.





VI. Selection

Although all types of corn are naturally cross-pollinating, they can easily be self-pollinated. However, keep in mind that corn is highly susceptible to *inbreeding depression*. Selection methods for sweet corn follow the basic structure outlined for cross-pollinated crops in OSA's *Introduction to On-Farm Organic Plant Breeding*. We highly recommend reading this introductory guide before delving into the specific strategies presented here. It is available for free download at www.seedalliance.org.

Most modern varieties are produced through an **inbred-hybrid system**. For informational purposes, the following section briefly explains this process. However, developing and maintaining hybrids is not generally appropriate for organic on-farm plant breeding for the following two reasons. First, **in-breds** can be very weak and hard to produce seed of on organic farms. Second, hybrid varieties cannot be rapidly adapted to new environments.

Inbred-hybrid development

This breeding system consists of two parts: inbred development and hybrid testing. During inbred development, crosses are made between promising parents, including inbreds, hybrids, and populations. Families are produced by self-pollinating ears, each of which is then planted to a single **family** row and evaluated. The best plants from the best families will again be self-pollinated to produce families for the following year. This process will continue for five or more cycles of self-pollination, producing very inbred plants. As these families become more inbred, they will tend to become weaker, smaller, and produce smaller ears. This loss of vigor is a normal part of the inbreeding process. However, the **inbreeding** process will also “fix” the desirable trait.

Starting after the fourth or fifth cycle of self-pollination, crosses are made between inbred families. The goal of these crosses is to find combinations of inbreds that, when paired, produce hybrid offspring with good hybrid vigor as well as the other desired characteristics. When good hybrid combinations are found, they will be tested for multiple years at multiple locations. If they perform

well over multiple years and locations, they may become commercially available varieties. These varieties are then maintained by periodically producing seed and plants of both inbred parents and remaking the hybrid cross.

Mass selection

Mass selection in sweet corn breeding can be done following the basic principles outlined in *Introduction to On-farm Organic Plant Breeding*, including growing in a uniform field and using a grid system to select evenly. One of the biggest challenges in breeding sweet corn, along with many other fruiting cross-pollinated crops, is that the ears can only be evaluated after pollination has occurred. This means that pollen from potentially undesirable plants has already spread throughout the population before evaluations. To address this challenge, practice as much early selection as possible, removing plants before pollination based on traits such as germination time, early vigor, and early plant height (remove the plants as soon as tassels emerge and before they've begun to shed pollen). When practicing mass selection, maintain as large a population as possible, saving seed from at least 200 plants each year.

Family selection

Family selection is used to make more rapid gains relative to mass selection in sweet corn breeding. Refer to the *Introduction to On-Farm Organic Plant Breeding* for the basic concepts of family selection in cross-pollinated crops. There are three commonly used types of families in sweet corn breeding: half-sib families, full-sib families, and self-pollinated (S1) families. A **half-sib family** can be produced in two ways. The first is by saving individual ears that have been open-pollinated. The kernels on each ear are all related through their maternal genetics but have paternal genetics as diverse as all of the plants in the population shedding pollen. The second way to produce half-sib families is by combining the pollen from several plants into one tassel bag before making a controlled hand pollination. Full-sib families are produced by making a controlled pollination from the tassel of one plant to the ear of another. **S1 families** are produced by self-pollinating a single plant.

Each of these family types have benefits and drawbacks depending on your goals. Half-sib families produced by open-pollination are the easiest to create and they retain the maximum amount of genetic diversity. On the other hand, that diversity makes the family less uniform and can make it harder to fix the desired traits and pick the best families. Half-sibs produced by controlled pollination allow you to be more selective in choosing which plants will cross with other plants. **Full-sib families** represent a middle approach. Full-sib families are relatively uniform, but the process of cross-pollination between plants reduces the potential for inbreeding depression while also creating more new genetic combinations relative to self-pollination. S1 or self-pollinated families are useful for a few reasons. First, they create the most uniform families of the three types listed here, which makes it easier to separate the good, or most desirable, families from the bad, or least desirable, ones. Second, self-pollination allows for the greatest expression of recessive traits that can then be eliminated by selection. (See *Introduction to On-farm Organic Plant Breeding* for more information on recessive traits.) Third, self-pollination allows for selection of ear traits after pollination because it excludes pollen from undesirable plants. Since the only pollen a self-pollinated plant receives is from itself, if the ear looks and tastes good, you can feel relatively confident that the seed will produce plants with similar ear quality. The drawback to generating families through self-pollination is that it is a strong form of inbreeding, and can quickly lead to inbreeding depression since no crossing is occurring between plants. In your breeding plan, you may find it beneficial to use a combination of these family types depending on the phase and goals of your work.

Selection techniques

This section includes brief descriptions of how to select for some of the important sweet corn traits in the field.

How to evaluate traits on a relative scale

To score a trait on a relative scale, assign a value to a plant or family based on a rating system. For example, you might score leaf size on a scale from 1 to 9, where 1 represents a tiny leaf and 9 represents a large one. When scoring traits, begin by walking the entire field to assess the range of expression within the population for the trait of interest. The plants or families with the worst or least desirable expression of the trait will be the 1 on your scale and the plants or families with the most desirable expression will be your 9. Then proceed to score all plants or families based on that range, attempting to use the whole range of scores from 1 to 9. More information on how to conduct these evaluations can be found in OSA's *On-farm Variety Trials: A Guide for Organic Vegetable, Herb, and Flower Producers*. Both this guide and data sheets for evaluating and selecting plants are available for free download at www.seedalliance.org.

Germination is really only measurable when selecting based on whole families or populations. It can either be measured in a controlled setting or in the field. Inside, you can use standard germination testing standards, or you can create stressful situations, such as germinating the seed under colder than normal conditions. Try to make sure that you are providing as uniform of conditions as possible. In the field, germination (and emergence) is measured by planting a known number of seed from each family or population and recording the number of plants that emerge after a set period of time. This can be highly susceptible to the depth of planting, compaction, and other factors, and is really only useful if extra care is taken to plant everything as uniformly as possible.

Early vigor can be evaluated by rating the size of the plants at a certain time after planting. For example, at four weeks, plants should be large enough and have put on sufficient growth so that differences in vigor are apparent and easily evaluated. As with ger-

mination, this trait is very susceptible to the effects of seeding depth and compaction.

Silk date is recorded when silks begin to emerge from the plant. For all dates, in addition to the actual date, you can record dates as days after planting or you can use **growing degree days (GDDs)**. Both silk dates and tassel dates are used to evaluate maturity.

Tassel dates are recorded when half of the tassels have shed their pollen.

Plant height is recorded at multiple points during the season and can be directly measured or evaluated on a scale.

Ear height is measured to the base of the ears. Anther color is recorded as a note. Corn anthers are typically either yellow or purple.

Disease resistance (including smut, rust, northern corn leaf blight, southern corn leaf blight, maize dwarf mosaic virus, Stewart's wilt, stalk rot, ear rot, and kernel rot) can be measured either by scoring on a relative scale or by estimating the percent of surface (leaf, stalk, ear, or other plant parts) infected. With all disease ratings, keep in mind that disease pressure may vary widely both within a field and from year-to-year. Before emphasizing selection for disease resistance, make sure you can find examples of severely infected plants throughout the field. These examples will indicate that the disease is present in sufficient quantity/pressure to cause infection and that there is variation in the resistance among your plants/varieties. If specific disease resistances are important traits in your project, include parents or varieties that are known to have some level of resistance as well as those that are known to be susceptible. Including these plants or varieties will provide a baseline for comparison.

Pest resistance (including corn earworm and European corn borer) is a challenging trait to select for. Corn earworm and European corn borer can be very devastating in areas where they are common, and resistance to them is limited. There are some existing varieties and populations that have varying levels of resistance either because of thick,

tight, long **husks**, or because of naturally occurring compounds present in the kernels and silks.

Drought tolerance can only be selected for when drought pressure is present. Drought tolerance is selected for by measuring traits such as tip fill, plant height, and the difference between the silk and tassel dates under drought stress. It is very important that there is equal stress throughout the breeding field. Available water can be measured with a water probe.

Lodging resistance, like drought resistance, can only be evaluated when circumstances allow. **Lodging** is when plants fall over, either from the roots or from the stalk. Conditions that promote lodging are wind and wet soils, or a combination of the two. Lodging can be rated on a relative scale or measured as a percent of plants that fell over.

The following traits involve harvesting an ear to assess quality. To evaluate these traits while still saving seed, you either need to be working with families or have multiple ears on a plant.

Silk color can be rated on a scale from light silks to dark silks. Consumers generally find dark silks unattractive in fresh market corn.

Row number is evaluated by counting the number of rows of kernels that surround the ear at its widest point. There is generally an even number of rows on an ear of sweet corn.

Tip fill is a measurement of how far up the tip of the ear the kernels go. It can be rated on a scale where full kernel development extending all the way to the tip of the ear is preferred. Hand pollinations often cause incomplete pollination and poor tip fill so keep this in mind while making selections when making controlled pollinations.

Row straightness can be evaluated on a relative scale from straight to less straight. Incomplete pollinations can reduce row straightness, so this is another trait that is less reliable when evaluating hand-pollinations.

Ear shape can be rated on a scale where uniform, cylindrical ears are generally preferred to triangu-

lar shaped ears.

Ear size can be measured by ear length and ear width. Inbreeding can rapidly reduce ear length. Husk appearance can be evaluated on a relative scale, with dark green husks generally preferred to yellowish husks.

Husk protection refers to how far the husk extends past the tip of the ear. It can be directly measured or scored on a relative scale with longer husks considered more desirable.

Ear leaf length is a measurement of the leaf that extends past the ear. It can be measured directly or scored on a relative scale with longer flag leaves considered more attractive to consumers.

Ease of ear detachment can be scored based on how hard it is to harvest the ear from the corn plant. Make sure only one person is harvesting and evaluating this trait to ensure consistency.

Ease of husking can be scored based on how hard it is to husk the ear. As with ear detachment, make sure that only one person is doing the husking and rating to maintain consistency.

Kernel color can capture two parameters. First is the color type. Sweet corn is typically white, yellow, or bicolor, with yellow being dominant to white. Corn kernel color is controlled by many genes that create pigment in various tissue layers, creating blue, red, green, and purple colors. However, colors besides yellow and white only appear after sweet corn has passed the stage where it is harvestable for fresh eating. The second parameter of kernel color is the intensity of color. In general, sugary enhanced corn tends to have paler kernels relative to sugary and super sweet types.

Sweetness is a complex trait, and is controlled by a number of both major and minor genes. The *su1* gene increases sugar and **water-soluble polysaccharides (WSP)** above those in non-*su1* corn. The *se* gene modifies the *su1* gene, and when both are present, sugar and WSP are increased. The *sh2* gene greatly increases sugar content over these other types but results in lowered WSP in the kernels. Because corn carrying the *sh2* gene has

less WSP than *su1* or *su1 se* types, it tends to be perceived as less creamy. Sweetness can be rated subjectively by taste testing. Brix testing is used to evaluate sweetness, but it is important to note that Brix testing uses a refractometer to measure soluble solids rather than just sugar alone. This means Brix testing can be an unreliable means of determining sweetness.

Flavor can be rated on a scale or recorded as descriptive notes reflecting any exceptionally good or off-flavors beyond sweetness.

Tenderness can be evaluated on a scale through taste tests. Tenderness refers to the thickness of the seed coat (**pericarp**). The thicker it is, the less tender the kernels are. However, in general, seed with thinner pericarps are more prone to problems with germination and cold soil emergence.

Kernel depth is most easily evaluated on a scale during taste tests. However, it can also be measured directly on dry kernels.

Breeding timeline

The following timeline is based on OSA's approach to breeding cross-pollinated crops.

Year 0: Set your breeding goals and evaluate potential parents based on how well they meet your goals. Use variety trials to help you evaluate and determine which varieties or other parental material to use in your breeding work. See OSA's *On-farm Variety Trials: A Guide for Organic Vegetable, Herb, and Flower Producers* for more information on conducting variety trials.

Year 1: If necessary, make crosses between your selected parents. The crosses can be made through open pollination, detasseling, or hand pollination as appropriate (see **Reproductive Biology and Pollination Techniques** section above).

Years 2-4: Plant a population of at least 250 plants from the previous year's crosses and allow them to freely cross-pollinate. Remove the least desirable plants, discarding approximately 10 to 20% of the total population. Save seed from at least 200 plants each year to help avoid inbreeding depression. It is important not to select too aggressively at this

point because the genes from the parents are still combining together and settling into reliable and predictable arrangements.

Year 5: At this point, if you would prefer to only practice mass selection, continue to do so, selecting more heavily than before, but still saving seed from a minimum of 200 plants.

Alternatively, you can begin family selection. You can approach this in one of two ways: by creating half-sib or S1 families. To create half-sib families, first remove all of the undesirable plants before pollination and then allow the remaining plants to cross-pollinate. Select ears from at least 100 to 200 of the best plants in the field and keep them separate. Each ear represents a half-sib family. Give each family a number. To create S1 families, self-pollinate as many desirable plants as you can, preferably 500 to 1000 plants. Select the 100 to 200 best plants out of the self-pollinated plants. Save the seed separately from each ear, giving each family a number.

Year 6: If practicing mass selection, continue as in Year 5.

If practicing family selection, plant one short row of 10 to 20 plants per family. If space allows, you can plant a second replication by planting all of the family rows twice. Save some seed from each family to serve as remnant seed for later planting. Evaluate all of the families for the traits of interest. Select at least 20 families from the original 100 to 200 plants. Because corn pollinates before you can evaluate the ears, we recommend that you do not save the seed of these families, but instead use the remnant seed of the best families for next year.

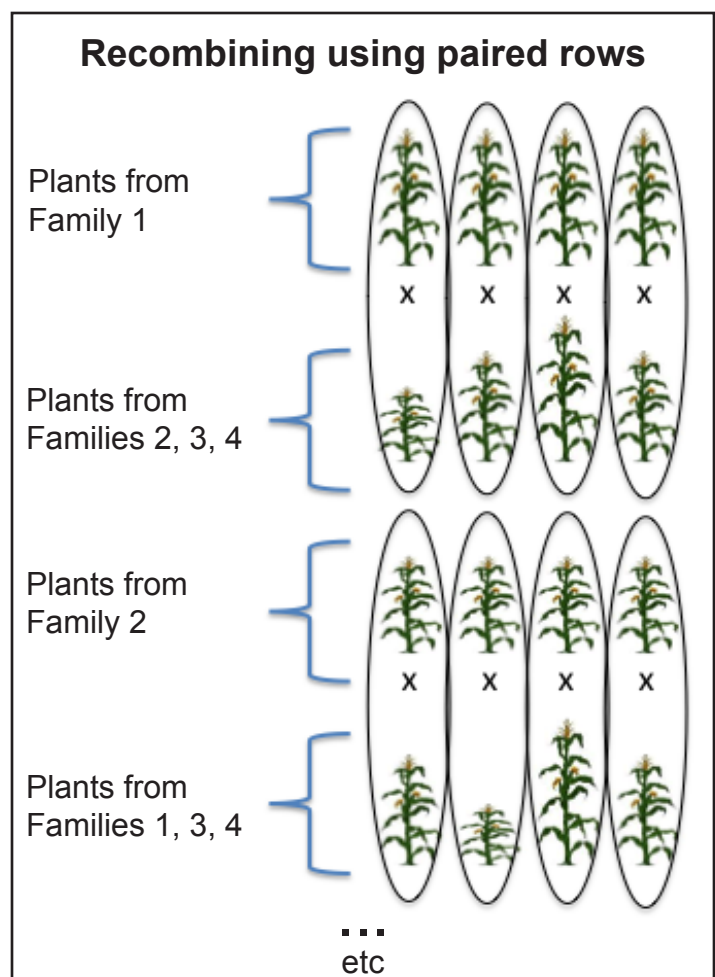
Year 7: If practicing mass selection, continue as in Year 6.

If practicing family selection, this year you will recombine (cross) your selected families. There are a few ways to recombine your families depending on your plans for the following years. If you are satisfied with the progress you made using family selection and wish to recreate a population that you will maintain via mass selection, combine equal amounts of seed from each family, plant the

seed, and allow the plants to openly pollinate. If you would like to create full-sib families, plant the families in the following **paired row** scheme with controlled hand pollinations:

- In the first row, plant seed from your first family
- In the second row, plant seed that has been combined from all of the families except the first family
- In the third row, plant seed from the second family
- In the fourth row, plant seed that has been combined from all of the families except the second family.
- In the fifth row, plant seed from the third family
- In the sixth row, plant seed that has been combined from all of the families except the third family.
- Continue in the same fashion for the remaining rows, planting a row with seed from a single family followed by seed combined from all of the other families.

Hand-pollinate each plant in the first row with pollen from a plant in the second row and vice-versa. Then hand-pollinate plants from the third row with



pollen from the fourth row and vice-versa, and so on. Save seed separately from each ear, as these will be your families for next year.

Year 8 (and beyond): If practicing mass selection, continue as in previous years. If continuing another cycle of family selection, plant and evaluate family rows as you did in year 6. Next year recombine them as in year 7. Once you are satisfied with your variety, combine the seed as described in year 7.

Glossary

Anthers: male, pollen-bearing structures. A corn tassel contains hundreds of anthers.

Anthesis: in corn, the period when a corn plant is shedding pollen.

Detasseling: the act of removing the tassel from a corn plant or corn plants.

Endosperm: a starchy tissue that constitutes the majority of the material inside each corn kernel.

Family: a group of genetically related plants. Often the nature of the relationship is specified. As examples, see *half-sib families*, *full-sib families*, and *S1 families*.

Family selection: selecting plants or families based on the overall performance of a family.

Full-sib family: a family structure where the plants in the family share the same mother and the same father.

Growing degree days (GDD): A measurement of accumulated heat throughout the growing season. In corn, GDDs are calculated in the following fashion: for each day after planting, find the average daily temperature. If the average temperature is less than 50° F, record it as 50° F. If the average temperature is greater than 86° F, record it as 86° F. Subtract 50° F from the average. This is the number of degree days accumulated that day. Continue this process for each day, adding each day's degree days to the total. For example, if the average daily temperature the day after planting was 55° F, then 5 (55-50) GDDs were accumulated that day. If, on the following day, the average daily temperature was 75° F, then 25 (75-50) GDDs were accumulated that day, and a total of 30 GDDs were accumulated since planting.

Half-sib family: a family structure where the plants in the family share the same mother.

Husk: the leafy outer covering of an ear of corn.

Hybrid: the product of a cross between genetically distinct parents.

Inbred: a variety produced by inbreeding over a number of generations.

Inbred-hybrid system: a method of producing varieties by first developing a number of inbreds, followed by testing hybrids created from crosses of these inbreds.

Inbreeding: mating between related individuals.

Inbreeding depression: the decrease in varietal fitness due to inbreeding.

Kernel: a seed of corn.

Lodging: a phenomenon whereby corn falls over during the growing season. Lodging typically occurs during wind events. It can occur as stalk lodging, which occurs when the corn stalk breaks, or as root lodging, which occurs when the plants pull out of the ground at the roots.

Mass selection: a form of selection where individual plants are selected based on their individual performance.

Paired rows: a scheme for arranging plants to be crossed so that two adjacent rows are crossed with each other.

Pericarp: the outermost layer of a corn kernel.

S1 family: a family structure where the plants in the family all resulted from the same self-pollination.

Setting up: preparing the corn shoot and tassel for a future pollination.

Shoot: a developing husk and ear of corn.

Shoot bag: a waterproofed paper bag designed to fit over a shoot and protect it from unintended pollinations.

Silk: the styles and stigmas of corn.

Silking: the period when silk emerges from the corn shoot and is receptive to pollination.

Sugary: sweet corn homozygous for the *su1* gene, with increased sugar and water soluble polysaccharide content over non-sweet corn.

Sugary enhancer: sweet corn that is homozygous for both the *su1* gene and the *se* gene. Sugary enhancer corn has more sugar than sugary corn, and has more water soluble polysaccharides than supersweet corn.

Supersweet: sweet corn that is homozygous for the *sh2* gene. Supersweet corn has increased sugary content relative to sugary corn, but has less water soluble polysaccharides.

Taking down: completing corn pollinations.

Tassel: a male inflorescence of a corn plant.

Tassel bag: a waterproofed paper bag used to capture pollen from tassels.

Water soluble polysaccharide (WSP): a class of molecules made up of a small number of sugars bonded together. WSP gives sugary and sugary enhancer corn their creamy texture.

Xenia: effects that occur due to the influence of pollen and are observable in the year that pollination occurred.

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