

Crop Profile for Sweet Corn in Minnesota

Prepared: October, 2001



General Production Information

Minnesota is the second largest producer of processing sweet corn in the United States, averaging 129,900 acres of planted sweet corn from 1995 to 1999. Over this same period, yields averaged 766,420 tons/year (6.19 tons/acre). The average return for Minnesota sweet corn was \$72.60/ton with an average annual production value of \$55.5 million from 1995-99 (15).

Production Regions

The majority of sweet corn grown for processing is produced in southwest, south-central, and southeastern Minnesota. Renville (>25,000 acres annually), Brown (>10,000 acres), and Faribault (>8,000 acres) counties led the state in production for the 2000 growing season; all are located in the

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southern portion of the state. Most sweet corn for processing is grown near processing or canning facilities which are located throughout southern Minnesota (14).

Executive Summary -Sweet Corn

For the past 5 years, Minnesota has been one of the leading states (ranked #1 or 2 nationally) for total sweet corn production, with ca. 129,000 ac for processing and 11,000 ac for fresh market. The average return for Minnesota sweet corn for processing was \$72.60/ton with an average annual production value of \$55.5 million from 1995-99 (15). The average return for 11,000 ac of fresh-market sweet corn (assuming 18,000 useable ears/ac at \$2.50/dozen) is ca. \$3,750/ac or \$41.2 million.

In addition to the direct value to the sweet corn processing industry, sweet corn contracts with growers play a key role in economic diversification for many traditional soybean/field corn growers throughout southern Minnesota.

The high value of this crop, along with the potential for economic losses from insect, disease and weed pests, continue to create demand for effective integrated pest management (IPM) programs. In response to new IPM information needs generated by the Food Quality Protection Act (FQPA), this crop profile was developed to a) summarize current IPM practices for insect, disease and weed pests, b) highlight pesticides under review by US-EPA, c) estimate the impact of the loss of selected pesticides, and d) assess alternatives for such losses.

In most years, insect pests are the most damaging and difficult to control in Minnesota sweet corn. The most important and consistent insect pest is the European corn borer (2, 3, 16). Corn earworm is also very devastating, but damage is usually limited to late-planted, or late-maturing hybrids silking in mid-August to early Sept. (2, 3). Other occasional insect pests include: flea beetles, corn leaf aphid, and a new introduction to Minnesota, the western bean cutworm (17).

Common rust is usually the most damaging disease problem, but recently labeled fungicides (Tilt and Quadris) provide good to excellent control. Many broadleaf and grass weed species are potentially very damaging. Because of a wide range of hybrid sensitivity to herbicides (particularly among fresh market hybrids), many registrants are reluctant to seek labels for sweet corn. However, in tandem with timely cultivation, most weeds are still controlled well with currently labeled herbicides. The recent registration of Aim provides a new option for processing sweet corn; over 25 processing hybrids are now approved for use.

Insects: During the past two years (2000-2001), multi-state and multi-year reviews of pyrethroid efficacy against ECB and CEW have been published, confirming excellent control by Capture, Warrior, Pounce and Baythroid against each pest (11, 12). The most recent report, however did indicate that Warrior appears to provide the most consistent control of corn earworm in Midwestern sweet corn (11).

The only “reduced-risk” insecticide tested thus far, SpinTor (actinomycete bacterium), shows considerable activity on ECB (Hutchison, unpublished data); very little data are available for CEW. One of the most intriguing control tactics for ECB and CEW is the use of transgenic sweet corn, transformed to express Cr1Ab toxin of the bacterium, *Bacillus thuringiensis* (Bt) (2,3). Although the technology works very well, marketing concerns have precluded much use in the U.S. However, some fresh-market growers (minimum size of 40 ac.) continue to utilize Bt hybrids.

Traditional foliar Bt products (e.g., Dipel), as well as the carbamate insecticide, Sevin, continue to be popular choices among smaller fresh-market growers, primarily because of the non-RUP status. Future FQPA reviews of carbamates, however, that might limit use of Sevin, would create new challenges for many growers.

Diseases: Many of the damaging diseases in sweet corn, such as Common Smut, are not treatable with fungicides. Others, however, such as Common Rust, are treatable with a variety of fungicides, including recent registrations of Tilt and Quadris. If the older mancozeb products became vulnerable to FQPA, the newer products could be used, albeit at a higher cost. In some cases, growers can continue to rely on resistant (various degrees) varieties to assist with disease control. For example, “rust-resistant” Jubilee continues to be effective (single *rpd* gene resistance). Some hybrids also provide moderate levels of resistance to Stewart’s Wilt. However, for Stewart’s Wilt, new seed treatments (Gaucho, Adage) may provide consistent and effective control. When the mancozeb products come under review with respect to FQPA, there will be a renewed need to assess risks/benefits.

Weeds: For both broadleaf and grass species control, processors have several herbicide options. Fresh-market growers, however, have fewer options. Over the past 5 years, the most “at-risk” herbicides in sweet corn have been Atrazine-based products, due mainly to groundwater concerns on sandy soils. As a result, use of Atrazine has been restricted in many growing regions of Wisconsin. Currently, the major limitations in weed control reside with fresh-market growers. As noted in this profile, many of the herbicides, including the most recent products, are limited to use with processing hybrids. If and when the older, non-RUP herbicides come under review via FQPA, there will be a renewed need to assess risks and benefits of each.

Cultural Practices

Sweet corn is planted from early May through July. Commercial growers will stagger their planting dates to allow adequate time to harvest the crop over several weeks late in late summer.

Sweet corn is planted approximately 1 inch deep with plant spacing ranging from 6-10 inches within rows. Rows are typically spaced 30-40 inches apart. This translates to 26,000-36,000 seeds/acre or

about 10-15 pounds/acre. The minimum soil temperature for germination is 50°F. Temperatures should reach a minimum of 60°F for supersweet varieties because germination is drastically reduced under cooler soil conditions. Generally, sweet corn takes approximately 14 days to emerge from 50°F soils, but considerably less, about 5 days, to emerge at 70°F. Soil temperature is a key factor to consider when scheduling plantings. Proper management practices are essential if optimum fertilizer responses are to be realized. These practices include the use of recommended varieties, selection of adapted soils, weed control, disease and insect control, proper seed bed preparation and seeding methods, and a timely harvest. Optimum pH for sweet corn production is 5.8-7 and adding lime is recommended if soil pH is <5.8. The need for lime can be determined from routine soil tests. Lime is applied before planting and incorporated to a depth of approximately six inches. Soil tests provide an accurate measure of fertilizer needs (8).

Producers who grow sweet corn on contract are usually given recommended planting dates for the corn hybrids they grow by the contracting processor. Average field size for sweet corn produced under contract ranges from 40-80 acres. Sweet corn for processing is generally machine harvested in Minnesota from the end of July to late-September and begins when kernels of standard varieties reach 70-74% moisture. Corn must be protected from overheating and transported to the processing facility as soon as possible following harvest to avoid damaging the product (8).

Insect Pests

There are numerous insect pests of sweet corn that can damage plants at all stages of development. The following insects can be categorized as major to minor/occasional pests based on the level of damage they are capable of causing annually.

Major (annual) pests of processing sweet corn:

European corn borer (*Ostrinia nubilalis* Hübner)

European corn borer (ECB) is the most damaging pest of sweet corn in Minnesota on an annual basis. Damage caused by the insect is estimated to be \$36.9 million annually in Minnesota in the absence of control measures (16). European corn borer overwinter as a fifth instar larvae in corn stalks, stubble, and debris within fields with larvae pupating in the spring and adults mating upon emergence. Females lay eggs from late May-June. First generation larvae feed on the whorl-stage plants causing characteristic feeding holes or “shot-holing” to be expressed as the leaves enlarge and expand. Second-generation ECB larvae are present from late July-August and tunnel into ears and stalks. Larvae present in stalks can cause breakage and lodging of the plants which diminishes yield. Larvae feeding on ears causes considerable damage by reducing yield and creating damaged and unmarketable ears. Scouting fields for the presence of ECB is the key to management. A variety of traps (pheromone and blacklight) can be used to monitor fields for populations of adult corn borer. Knowledge of moth flight activity is

critical for timely in-field scouting and decision-making regarding treatment options. Timing of insecticide applications is critical because once larvae have entered the protective covering of the husk, conventional insecticides are ineffective at reaching the larvae.

Also see factsheet: <http://www.ent.iastate.edu/pest/cornborer/htm>

Corn Earworm (*Helicoverpa zea* Boddie)

Corn earworm is a significant pest of sweet corn in Minnesota. Adults originate from the southern U.S. because they are unable to overwinter in northern climates. Adults are 0.75-1 inch long with a wingspan of 1.5-2.0 inches and are tan/buff colored with characteristic green eyes. Adult females lay eggs on foliage, either on leaves early in the season or on fresh silks later in the season. The eggs hatch after 5-7 days and larvae pass through six instars before pupating. Larvae can possess green, tan, pink, dark brown or black coloration and inhabit the tip region of ears. Two generations are typically observed in Minnesota, the first appearing in mid-June when corn is at whorl stage and the second, more destructive generation taking place in early-mid August when most processing sweet corn is producing ears. The late season generation is responsible for the majority of insecticide treatments applied to late-season processing sweet corn. One larva can render an ear unmarketable as corn earworm larvae are able to consume considerable kernel tissue and leave considerable frass (excrement) throughout the ear. Proper timing of insecticide application is critical as there are no control options once larvae enter the protective covering of the husk. Frequent insecticide applications are typically made on set schedules to insure the crop remains clean and marketable. Treatments are most effective during the silk stage prior to larvae entering the ear.

Also see factsheet: <http://www.vegedge.umn.edu/vegpest/cewbean.htm>

Minor (sporadic/occasional) pests of processing sweet corn:

Fall Armyworm (*Spodoptera frugiperda*)

As this species cannot overwinter in the Midwestern U.S., the fall armyworm migrates northward each year from the southern, gulf coast states. Migrations to Minnesota, however, are sporadic, with significant infestations developing about every 3-5 years. Larvae vary in color from light tan to black but all possess a characteristic inverted “Y” on their head capsule. Larvae can reach lengths of 1-1½ inches and are typically not seen in Minnesota until late in the growing season. The timing of fall armyworm arrival to Minnesota coincides with sweet corn ears nearing maturity, and as such, damage caused by the larvae can be significant. Control of fall armyworm is achieved through the use of insecticide treatments similar to those used to for ECB and corn earworm management.

Also see factsheet: <http://www.uky.edu/Agriculture/Entomology/entfacts/fldcrops/ef110.htm>

Seed corn maggot (*Delia platura*)

Seed corn maggot is considered an occasional pest of sweet corn with resulting damage being highly variable from year to year. Insects overwinter as pupae in the soil and mate upon emergence in the spring. Although multiple generations are present throughout the growing season, first generation maggots are responsible for the majority of damage (e.g., attacking May plantings). Adult females lay eggs in the soil and upon hatching, the maggots feed upon the roots. Sweet corn stands can be significantly reduced by seed corn maggot. Poor germination and emergence problems can be the result of infestations involving this insect. Surviving plants often have numerous small holes on their cotyledons, evidence of maggot feeding. Larger plants are more tolerant of damage and as such will typically not express symptoms of feeding damage.

Also see factsheet: <http://www.vegedge.umn.edu/vegpest/seedmag.htm>

Sap beetles (*Carpophilus dimidiatus*)

Sap beetles, also called the picnic beetles or four-spotted sap beetles, are approximately 1/4 inch in length and easily identifiable by the four yellow patches which line the edge of their wing covers and their clubbed antennae. The insects overwinter as adults in the soil or field debris and emerge in the spring. Beetles can be found in sweet corn ears where bird, raccoon, and other wildlife have damaged the tips, causing the plant material to begin decomposing. Picnic beetles are strongly attracted to damaged ears which often contain the fermenting juices of rotting and decaying kernels. These damaged areas serve as entry points for the beetles in addition to European corn borer tunnels. Sap beetles can also be responsible for the introduction of disease pathogens into ears. Management of beetles can be accomplished through the use of appropriate cultural controls such as debris management in the fall. In the case of extremely high densities, insecticide treatments can be made (7, 9).

Black Cutworm (*Agrotis ipsilon*)

Black cutworm adults migrate to Minnesota from early March through mid May and lay eggs in vegetation in and around cornfields. Larvae feed on available vegetation upon hatching. Early instars feed on corn leaves while later instars cut plants off near the ground. Fields subject to cutworm infestation often have pre-plant infestations of weeds, heavy surface debris, poor drainage, or a history of cutworm damage. The most serious damage caused by black cutworm is feeding on young sweet corn seedlings. While small cutworm larvae (1st-3rd instars) feed primarily on corn leaves, larger larvae (4th and later instars) will cut plants off at or just above or below the soil surface. In cases where the growing point is destroyed or the plant is cut below the growing point, the plant will not survive. Large numbers of black cutworm can drastically reduce the plant stand in given fields. Although some growers will apply soil insecticides prior to or at planting to prevent cutworm infestations, this is not an economically justified action. Infestations can be described as sporadic, at best, and difficult, if not impossible, to predict. Growers should scout their fields looking for cutworm damage and apply therapeutic or “rescue” insecticide treatments only if damage exceeds an economic threshold.

Also see factsheet: <http://www.mnipm.umn.edu/bugweb/bugbase/cutwormnetwork/information/migration.html>

Corn leaf aphid (*Rhopalosiphum maidis*)

Corn leaf aphids often reach high densities during late-whorl to early-tassel growth stages, particularly from June to July. High aphid densities can cause wilting and curling of leaves and ultimately necrosis in the upper leaves of plants. Aphids excrete a waste product, honeydew, which covers leaves, tassels, and silk and can interfere with pollination during reproductive stages. Certain varieties of corn favor aphid survival while others have been developed which result in lower aphid density. In most instances a variety of natural enemies, including fungi and lady beetles, cause significant aphid mortality and rapid demise of aphid infestations. Treatment thresholds are not well developed for this species.

Corn rootworm (*Diabrotica spp.*)

Larvae are the most destructive stage of corn rootworm beetles. The larvae develop through three instars while feeding on the exterior or roots or tunneling into roots during throughout the summer. While feeding, larvae prune roots back to the stalk. The root system then becomes weakened which hinders water and nutrient uptake by the plant. Additionally, feeding damage can cause plants to lodge (fall over) which can disrupt harvest. Yield losses result from both root pruning and lodging. The corn rootworm complex consists of three important species: northern corn rootworm, southern corn rootworm, and western corn rootworm. Management is accomplished through crop rotation or through the use of soil insecticides to prevent severe injury to the roots. Throughout most of Minnesota, a corn-soybean rotation continues to be an excellent management tool for rootworm larvae because larvae survive only on corn roots and adults lay few eggs in soybean. Additionally, rootworms complete one generation annually. A corn-soybean rotation may fail to control rootworms when volunteer corn plants in a soybean field attract egg-laying beetles or when rootworms exhibit extended diapause, a biological phenomenon that allows some eggs, primarily those of northern corn rootworms, to remain dormant in the soil for more than one winter. This trait has become more common in Illinois and Indiana within the last few years. Corn planted on corn is more susceptible to injury by corn rootworm larvae, depending upon the rootworm population. Most producers who grow corn on corn in the region will apply a granular soil insecticide at planting to protect the corn roots from larval feeding injury. However, because of concerns with volunteer field corn, most sweet corn growers, will only plant sweet corn in fields that had been in beans, or something other than field corn the previous year.

Also see factsheet: <http://www.ag.ohio-state.edu/~ohioline/icm-fact/fc-16.html>

Corn flea beetle (*Chaetocnema pulicaria*)

Several species of flea beetle are observed in Minnesota including potato flea beetle, threespotted flea beetle, and palestriped flea beetle. The corn flea beetle, however, is considered the primary vector of bacterial wilt, which is typically a major concern early in the season. Flea beetles have enlarged hind legs enabling them to jump when disturbed. Feeding damage in sweet corn disrupts physiological processes and is most severe when corn is <6 inches tall, and when stressful growing conditions are present. Flea beetle control can be achieved through keeping fields weed-free and when warranted, with the use of resistant hybrids, and insecticide treatments.

Also see factsheet: <http://www.vegedge.umn.edu/vegpest/swtcorn/cflea.htm>

Insect Control Options

A 1990 survey of six Minnesota sweet corn processing companies found that European corn borer and corn earworm were the major pests of processing sweet corn. For that year, 77% of the total processing sweet corn acreage was treated with pyrethroids (primarily permethrin) to control either European corn borer or corn earworm (4, 5, 6, 10). As of the 2001 field season, pyrethroids continued to be the dominant insecticides used in Minnesota sweet corn, particularly Capture, Warrior and Pounce (WDH, unpublished data).

Control options for sweet corn insect pests (type of control/insecticide class):

Organic/Alternative:

Bacillus thuringiensis (Dipel DF, Javelin WG) *Bacillus thuringiensis* (Bt) products can be applied as foliar insecticides for control of European corn borer, and to a limited extent, CEW. Products are applied at a rate of 0.12-1.5 lbs./A. Field re-entry interval (REI) is 4 hours.

Spinosad (SpinTor 2SC) SpinTor is biologically derived from the fermentation of the soil organism *Saccharopolyspora spinosa* and can be used to control Lepidopteran larvae on a variety of crops, including sweet corn. Data thus far indicate that Spinosad is very effective against European corn borer, but may only provide moderate control of corn earworm. The product is applied at a rate of 0.02-0.10 lb./AI/A.

Insecticidal control options:

Carbamates

Carbaryl (Sevin XLR Plus) Sevin can be used to control corn rootworm adults and European corn borer and corn earworm larvae. There is a 12-hour REI for Sevin and ears cannot be harvested for 2 days following the last application. The labeled rate for Sevin in sweet corn is 1-2 quarts/acre with total field-applied product not to exceed 16 quarts/acre in one growing season.

Methomyl (Lannate LV) Restricted use product (RUP). Lannate is labeled to control European corn borer and corn earworm eggs, picnic beetle, aphids, and corn rootworm. The labeled rate is 0.23-0.45 lb. AI/A and there is a field REI of 48 hours for this product. Lannate can be used to enhance ovicidal activity (e.g., tank mix with pyrethroid) but should not be used solely for corn borer or corn earworm control.

Carbofuran (Furadan 4F) RUP. Furadan is a soil-applied insecticide used to control first generation European corn borer, flea beetle, corn rootworm beetle, and seedcorn maggots when applied after planting (< 2 weeks). Requires preharvest interval of at least 1 week when foliar applied to control second generation European corn borer. The labeled rate is 0.22-0.44 lb. AI/A.

Pyrethroids

Esfenvalerate (Asana XL) RUP. Asana is labeled for use on sweet corn to control European corn borer, corn earworm, sap beetles, cutworm, and corn leaf aphids. The labeled rate is 0.03-0.05 lb. AI/A with total annual applied product not to exceed 0.5 lb. AI/A. Asana can be applied up to 1 day before harvesting sweet corn. Asana provides good corn earworm control, but should not be used for European corn borer control (e.g., Hutchison 1993). The 1990 survey found 1,440 lbs. AI of Asana was applied in Minnesota.

Bifenthrin (Capture 2EC). RUP. Registered in the late 1990s, this pyrethroid is effective on both ECB and CEW. Total product applied per season must not exceed 0.2 lb. AI/Ac (12.8 oz. formulated product) and there is a 1-day pre-harvest interval. Note: the REI is 24 hours for processing sweet corn and 18 days for fresh market sweet corn.

Lambdacyhalothrin (Warrior T). RUP. Warrior can be used to control European corn borer, corn earworm, corn rootworm adults, sap beetle, aphids, and cutworm. The labeled rate of application for the product is 0.02-0.03 lb. AI/A. Total product applied per season must not exceed 0.48 lb. AI/A and there is a 1 day pre-harvest interval.

Permethrin (Pounce 3.2, Ambush). RUP. These products control insects including: European corn borer, corn earworm, aphids, sap beetles, and corn rootworm adults. All of these products have 1-day pre-harvest intervals. Restrictions limit the cumulative product that can be applied in one growing season (this amount varies by specific product, see individual label for detail). A 1990 sweet corn insecticide survey found that > 63,000 lbs. AI of Pounce were applied to processing sweet corn fields in Minnesota to control European corn borer and corn earworm.

Cyanomethyl-3-2,2-dimethyl-cyclopropanecarboxylate (Baythroid 2E). RUP. This pyrethroid is effective on ECB and CEW. However, it has not gained a large percentage of the market share in MN. Total product applied per season must not exceed 28 oz./Ac and ten applications. There is a 0-day pre-harvest interval for Baythroid.

Organophosphates

Diazinon (Diazinon 50W). RUP. Diazinon can be used to control corn earworm, sap beetles, corn leaf aphids, and cutworm. The product is applied at a rate of 2-8 lbs./A depending on the insect targeted and can be applied either to the soil or as a foliar-applied product. There is a 7-day pre-harvest interval for the product.

Chlorpyrifos (Lorsban 4E). RUP. The product is used to control European corn borer, corn earworm and corn rootworm on foliage at rates of 1-6 pints/acre. Additionally, the product can be used at planting to control cutworm or corn rootworm larvae and is applied at 2-2.6 pts./A. No more than 15 pints of Lorsban may be applied per acre in one growing season. There is a 35-day pre-harvest interval for fields treated with this product.

Transgenic Sweet Corn

Bt Sweet Corn. Sweet corn transformed to express various toxins from the bacterium, *Bacillus thuringiensis* (Bt), was first tested in Minnesota in 1995 (2, 3). Several Bt sweet corn hybrids provide excellent control of European corn borer and corn earworm. Due to current marketing concerns, however, very little Bt sweet corn is currently produced for processing markets. Fresh market growers (minimum 40 acres) continue to utilize the technology.

New products/registrations

Processing sweet corn hybrids genetically engineered with the *Bacillus thuringiensis* (Bt) gene have been planted in Minnesota over the past several years. Transgenic Bt corn offers season long control of European corn borer and suppression of corn earworm.

A new product, marketed by Eden Bioscience Corporation, called 'Messenger' is touted as enhancing plants' natural suppression systems, thereby minimizing insect feeding damage. The AI in Messenger is a byproduct of bacteria, thus it is considered a biological or biochemical product. An additional claim made by the manufacturer is added disease suppression.

Diseases

There are several diseases that affect sweet corn in Minnesota. The frequency of occurrence of the following diseases is highly dependent on the weather and other environmental factors encountered throughout the growing season (4, 5, 6, 18).

Fungal Diseases

Common Maize Rust (*Puccinia sorghi*)

Rust can appear on any above ground part of corn but most often initially develops on leaf tissue. The disease develops into circular or oblong, reddish-brown, spore-containing pustules. This disease is transmitted into corn production areas from temperate, corn producing regions via favorable wind patterns. Cool temperatures coupled with high humidity favor rust development in sweet corn fields. Control may be achieved by selecting resistant varieties and applying fungicide treatments at appropriate times.

Common Smut (*Ustilago maydis*)

Common smut is present throughout the world and is observed on Minnesota sweet corn annually. The extent to which the smut infests fields and causes economic losses to a given area varies annually. The disease causes gall formation on leaves and/or ears of affected plants. Galls that form on ears burst open

late in the season and release millions of teliospores. The teliospores land on the soil where they overwinter and germinate in the spring. Upon germination, they release basidiospores. Basidiospores are transferred to developing corn plants via wind and/or rain. The development of this disease on sweet corn is encouraged by warm, dry conditions with ideal temperatures ranging from 80-95° F. Plants that have been damaged by wind-blown sand, hail, or other weather phenomena and grown in soils high in nitrogen and/or organic matter (manure) will be more prone to become infected by smut. Control is achieved by selecting resistant varieties of sweet corn, minimizing plant injury by mechanical equipment while cultivating, and maintaining balanced soil fertility throughout the field.

Northern corn leaf blight (*Exserohilum turcicum*)

Northern corn leaf blight symptoms include gray, striped lesions on the leaves which progress upwards from the bottom of the plant. In severely affected plants, leaves will turn completely gray and eventually die. The disease also can cause plants to appear as though they have suffered frost or freezing injury. Many of the symptoms of northern corn leaf blight are similar to Stewart's disease. Unlike Stewart's disease, however, northern corn leaf blight overwinters in affected leaf and stalk tissue from the previous corn crop as opposed to being vectored by insects as Stewart's disease is. Northern corn leaf blight is transferred as spores originating from debris early in the growing season and again following the development of lesions on living plants. Spores are able to travel great distances with the aid of the wind following the development of lesions on living plants. Development of the disease is aided by moderate temperatures, 64-80° F, and the presence of heavy morning dew which creates the ideal environment for fungal growth. Northern corn leaf blight can be managed through the use of resistant varieties, appropriate timed fungicide applications and proper cultural practices.

Anthracnose (*Colletotrichum graminicola*)

Anthracnose can be a very destructive disease that affects corn worldwide. The disease can be expressed throughout all stages of plant development. Symptoms include tan colored lesions appearing on the stalk, leaf discoloration, and top die-back of plants. The disease is transmitted by spores which are carried aloft by the wind or transferred from the soil to plant via rain-splashed water. Symptoms of the disease appear within a week of infection. Anthracnose can cause a number of problems for plants including: seedling blight, crown rot, root rot, leaf blight, top dieback, stalk rot, and kernel infection. Because anthracnose persists in soil debris, specifically infected plant matter at or below the soil surface, managing this layer with proper field sanitation will provide some control. Two cultural practices that reduce plant debris are deep plowing and modifying tillage practices by reducing conservation tillage. Crop rotation and the use of resistant hybrids can also aid in the reduction and management of anthracnose in sweet corn.

Bacterial Diseases

Stewart's disease (*Erwinia stewartii*)

Stewart's bacterial wilt is an occasional problem in Minnesota. Plants begin to wilt soon after corn becomes infected with this disease. Characteristic symptoms are similar to those expressed by a plant experiencing a nutrient deficiency or drought conditions. Streaking pale green and yellow lines run parallel with veins will be exhibited by the leaves. Soon after, leaves will become bleached and die. Hollow cavities form near stalk bases in extremely infected plants and in these cases, plants will become

more susceptible to rots and other diseases. Flea beetles serve as the primary vector for the bacteria and as such, fields should be closely monitored for the presence of these insects. Control of the disease can be achieved through the use of resistant hybrids, especially during growing seasons following mild winters. New seed treatments (e.g., Gaucho, Adage) are currently being evaluated for flea beetle control.

Disease Control Options

Control options for sweet corn diseases:

Cultural practices/crop rotation

Cultural control practices can play an important role in the management of diseases in sweet corn. Most disease pathogens that affect sweet corn overwinter in field debris, on or below the soil surface, or are vectored by insects. As such, managing the amount of crop residue, organic matter, or fertilizer applied becomes critical to the suppression of many of the above mentioned diseases. Rotating crops can drastically reduce the presence of disease inoculum in fields. Crop rotation also benefits soil health as it allows nutrients to be cycled into the soil.

Organic/Alternative

Harpen protein (Messenger) The active ingredient in this product is a protein produced by bacteria. The product stimulates a plant's natural suppression system and enhances growth. For sweet corn, the labeled rate is 2.25-9 oz./acre. The product should be applied on 14-day intervals. The product can be applied up until harvest and there is a 4-hour REI.

Conventional Fungicides

Seed treatments:

Fludioxnil (Maxim XL, Maxim 4FS, Apron XL) Maxim and Apron are used to control certain seed and soil-born diseases in sweet corn such as damping off and seedling blight (*Pythium* spp. and downy mildew). Maxim should be applied at a rate of 0.167-0.334 oz./100 lbs. of seed based on the expected level of disease to be encountered in the field. Apron should be applied at a rate of 0.278-1.23 oz./100 lbs. of seed, also based on projected disease levels.

Captan (Captan Moly Seed Protectant) Captan protects seed and seedlings against seed and soil-born diseases such as damping off, seed decay, and seedling blights. The product is mixed with seed prior to planting at a rate of 2.4 oz./100 lbs. seed.

Foliar treatments:

Maneb (Maneb 80WP, Manex) Maneb 80WP and Manex are both broad-spectrum protectant fungicides registered to control leaf rust and blight. Manex is applied at a rate of 1.2 quarts/acre and Maneb 80WP is applied at a rate of 1.5 lbs. product/acre. The maximum amount of Manex that can be applied in one growing season is 6 quarts west and 18 quarts east of the Mississippi River. Total Maneb 80WP product must not exceed 6 lbs. AI west or 18 lbs. AI east of the Mississippi River. Both products should be applied at 3-10 day intervals and should not be applied within 7 days of harvest.

Propiconazole (Tilt) This product can be applied for controlling rust and leaf blight. For rusts, the recommended rate is 4 oz/acre with application continuing every 7-14 days. For control of leaf blights, recommended rates of 2-4 oz./acre with application every 7-14 days is suggested. There is a 14 pre-harvest interval for Tilt on sweet corn and total product applied per acre cannot exceed 16 oz. in a growing season. There is a 24-hour REI for this product.

Mancozeb (Dithane DF, Manzate 80WP, Penncozeb 80WP) These products are all used to control leaf rust and Helminthosporium leaf blight. Dithane and Manzate are applied at a rate of 1.5 lbs./acre while Penncozeb is applied at rates of 1-1.5 lbs. acre. All products are to be applied on 4-7 day schedules following disease observation. For all products, no more than 18 lbs. AI/acre may be applied per growing season east of the Mississippi River and 6 lbs. AI/acre west of the Mississippi River. All products have 7-day pre-harvest intervals and 24-hour REI.

Product	Field Rate	A.I. Rate	PHI/REI	Application Schedule	Remarks
Foliar Treatments					
Maneb 80WP	1.5 lbs/A	1.2 lbs/A	7 days/24 hrs	3-10 days	<18 lbs AI/A/year
Manex	1.2 qts/A	1.2 lbs/A	7 days/24 hrs	3-10 days	East of Mississippi River: <18 lbs AI/A/year; West of river, <6 lbs AI/A/year
Tilt	2-4 oz/A	NA	14 days/24 hrs	7-14 days	Rusts: 4 oz/A; Blight: 2-4 oz/A; <16 lbs AI/A/year
Dithane DF	1.5 lbs/A	1.125 lbs/A	7 days/24 hrs	4-7 days	East of Mississippi River: <18 lbs AI/A/year; West of river, <6 lbs AI/A/year
Manzate 80WP	1.5 lbs/A	1.2 lbs/A	7 days/24 hrs	4-7 days	East of Mississippi River: <18 lbs AI/A/year; West of river, <6 lbs AI/A/year
Penncozeb 80WP	1-1.5 lbs/A	0.8-1.2 lbs/A	7 days/24 hrs	4-7 days	East of Mississippi River: <18 lbs AI/A/year; West of river, <6 lbs AI/A/year

Seed Treatments			REI		
Maxim 4FS	0.08 oz/100 lbs seed	0.003 lb/100 lb seed	12 hrs	NA	controls damping off and seedling blight
Maxim XL	0.17-0.33 oz/100 lbs seed	NA	48 hrs	NA	controls damping off and seedling blight

Weeds

There are numerous weed pests that affect sweet corn fields. Weeds compete with sweet corn for available resources including soil nutrients and moisture. They can be divided into either annual broadleaf weeds or annual grass weeds (4, 5, 6).

Broadleaf Weeds

Many broadleaf weeds adversely affect sweet corn in Minnesota. Examples are: velvetleaf (*Abutilon theophrasti*), lambsquarters (*Chenopodium album*), pigweed (*Amaranthus retroflexus*), and giant and common ragweed (*Ambrosia trifida* and *Ambrosia artemisiifolia*, respectively). During early to mid-season, many weed species reach heights comparable to sweet corn and compete with the corn for available light and soil nutrients. In absence of control, weeds can significantly reduce yields.

Grasses

Annual grasses cause significant problems with sweet corn production because of their fast growth and ability to compete for resources. Additionally, they are tolerant to extreme moisture and temperature variation once established. They can be very difficult to eliminate from production areas and given their reproductive potential, they require management/control prior to seed-set. Examples are: foxtail (*Setaria spp.*), wild proso millet (*Panicum miliaceum*), and crabgrass (*Digitaria spp.*).

Broadleaf Herbicides:

2,4-D (Amine 4) Postemergence herbicide used to control broadleaf weeds at a rate of 0.5-1.5 pts./A. Cannot be applied when corn >12 inches high and special attention should be given to avoid drift.

Atrazine (Aatrex 4L) RUP. Can be applied pre or postemergence to control annual broadleaf weeds. Atrazine is applied at a rate of 1-2 qts./A for preemergence situations and 1-1.5 pts./A for postemergence conditions. The specific rate will depend on the soil type of the area to be treated.

Bentazon (Basagran) A postemergence broadleaf herbicide registered for the control of annual broadleaf weeds at a rate of 0.75-1 qt./A. The product should not be applied to injured corn stands.

Cyanazine (Bladex 4L) A preemergence broadleaf herbicide that is less effective on velvetleaf and pigweed. Applied at a rate of 1.0 qt./A. Can be tank-mixed with Dual II Magnum, Frontier or Prowl to improve control of annual grasses and pigweed.

Paraquat (Gramoxone Extra) RUP. A postemergence broadleaf and grass herbicide. Applied at a rate of 0.8 pt./A. Special equipment is required for use, see label. Corn should be at least 10 inches tall; if not, serious injury can result.

Carfentrazone (Aim 40WSG) A postemergence broadleaf herbicide. Just recently labeled, and limited to use on processing hybrids only; only for hybrids on the label.

Grass Herbicides:

Alachlor (Lasso 4E) RUP. A grass herbicide that controls foxtails, crabgrass, and fall panicum. Applied at planting or prior to emergence. Labeled rate is 2-3.25 pts./A depending on soil type.

Dimethenamid (Frontier 6E) A grass herbicide that controls foxtails, crabgrass, and fall panicum. The product is applied at a rate of 1-2 pts./A. Total applied volume not to exceed 1 quart/year/A. Applied pre-emergence for best results. There is a 50 day PHI with Frontier for sweet corn.

Metolachlor (Dual II Magnum) Applied at a rate of 1.33-2 pts./A, provides control of foxtail, crabgrass, and fall panicum. Can be applied either at planting or prior to emergence.

Nicosulfuron (Accent) Accent is a postemergence grass herbicide applied at a rate of 0.66 oz./A. Application to sweet corn used for processing hybrids only, and only on labeled hybrids. Additionally, there should be no application of organophosphate insecticides when using Accent herbicide. Intended for use with specific sweet corn varieties, see label for details.

Pendimethalin (Prowl 3.3 EC) Prowl can be used to control foxtail, crabgrass, and fall panicum. Applied at a rate of 1.8-4.8 pts./A. Applied at varying rates depending on soil type. Can be applied either pre or post emergence. Should be tank mixed with Atrazine for controlling emerged grasses. Processing hybrids only; only those on the label.

Weed control options: chemicals

Product	Field Rate	A.I. Rate	REI	Remarks*
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Preemergence				
Aatrex 4L (Atrazine)	1-2 qts./A	1-2 lbs/A	12 hrs	BL. applied at specific rates for soil types; apply at planting/prior to emergence
Bladex 4L (Cyanazine)	1 qt/A	1 lb/A	12 hrs	BL. apply immediately after planting; some supersweet (Sh2) varieties may be injured
Dual II Magnum (Metolachlor)	1.33-2 pts/A	1.27-1.91 lbs/A	24 hrs	G. apply at planting or prior to emergence; reate varies according to soil type
Lasso 4E (Alachlor)	2-3.25 pts/A	2-3.25 lbs/A	12 hrs	G. apply at planting or prior to emergence; reate varies according to soil type
Prowl 3.3EC (Pendimethalin)	1.8-4.8 pts/A	0.74-1.98 lbs/A	24 hrs	G. applied at specific rates for soils types; can be applied either pre/post emergence
Frontier 6E (Dimethenamid)	1-2 pts/A	0.75-1.50 lbs/A	12 hrs	G. 50 day PHI; total < 32 oz/A/year
Postemergence				
Aatrex 4L (Atrazine)	1-1.5 pts/A	0.5-0.75 lb/A	12 hrs	BL. apply to weeds <1.5"; total <2.5 lbs/AI/A/yr
Amine 4 (2,4-D)	0.5-0.75 pt/A	0.23-0.35 lb/A	48 hrs	BL. apply to corn >12" tall; avoid drift
Basagran (Bentazon)	0.75-1 qt/A	0.375 lb/A	48 hrs	BL. avoid application to injured corn stands
Gramoxone Extra (Paraquat)	0.8 pt/A	0.25 lb/A	12 hrs	BL, G.special equipment required; corn must be >10" tall; can severely injure corn
Accent (Nicosulfuron)	0.66 oz/A	0.03 lb/A	4 hrs	G. use only on select processing varieties, no OP insecticide use with

*G: grass, BL: broadleaf

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