

Crop Profile for Corn (Sweet) in Maryland

General Production Information



- Maryland ranked 14th in national sweet corn production in 1997 with 22,000 acres, and accounted for 1.6% of U.S. sweet corn production (1).
- In 1998, Maryland growers planted 11,800 acres and harvested 10,800 acres of sweet corn for the fresh market, with a total cash value of \$11,664,000 (2).
- Approximately 10,000 acres of processed sweet corn were planted in Maryland in 1997 (3), with a cash value of \$12,600,000.00 (4).
- Annual production cost for fresh market sweet corn in Maryland was about \$610.32 per acre, or \$7,323,840.00 total for 1997. For processed sweet corn, annual cost per acre was about \$286.90, which totaled \$2,869,000.00 in 1997 (4, 5).
- About 55% of sweet corn produced in 1997 was for the fresh market while 45% was for processing (3, 6).
- Stringent IPM programs are currently in use on nearly all processed sweet corn produced in Maryland (7).
- 77% of the fresh market sweet corn growers use IPM practices such as insect trapping, field scouting, or both on their farms (8).

Production Regions

- Counties west of the Chesapeake Bay (Allegany, Anne Arundel, Baltimore, Calvert, Carroll, Charles, Frederick, Garrett, Harford, Howard, Montgomery, Prince George's, St. Mary's, and Washington) harvest 57% of the state's fresh market sweet corn (6).
- Northern Eastern Shore counties (Caroline, Cecil, Kent, Queen Anne's, and Talbot) harvest 28% of the state's fresh market sweet corn (6).
- The Southern Eastern Shore counties (Dorchester, Somerset, Wicomico, and Worcester) harvest 15% of the state's fresh market sweet corn (6).
- All of Maryland's processed sweet corn is grown on the Eastern Shore. Generally, the early acreage is planted in the southernmost counties and then successive plantings are located in northerly distribution as the season progresses (3).

Cultural Practices

Sweet corn may be planted as early as the last week in March in Maryland, with successive plantings into early July (9). Prior to planting, the soil is tested to determine optimum nutrient and/or lime applications. Recommended nitrogen, phosphorous, and potassium levels differ slightly for fresh market and processed sweet corn (10). Sweet corn is generally seeded one inch deep at a rate of 12 to 15 pounds per acre (9) with a row spacing of 30 inches (7, 11). Plants are grown 8 to 12 inches apart within rows, depending upon the variety. It is grown in many types of soils, but light, sandy soils with a pH level of 6.5 are optimal (9). In counties west of the Chesapeake Bay about 40% of fresh market acres are no-till, with some counties, such as Anne Arundel and Baltimore counties as high as 60 to 80% (11, 12). On the Eastern Shore, fewer than 20% of fresh market sweet corn acres are no-till. About 10% of processors use no till planting (7, 12). Tilled fields are prepared by disking immediately after harvest of the preceding crop, to incorporate residues into the soil (5, 13). Manure or other organic materials may be added as well (10). About 50 acres (0.4%) of early fresh market sweet corn west of the Chesapeake Bay is planted into clear plastic. This technique allows growers to harvest by early July to take advantage of early markets (11). Irrigation during critical periods such as silking, tasseling, and ear development is used by some fresh market growers and all processors to increase both the quality and yield of sweet corn. Cover crops, such as rye or wheat, are typically used prior to seeding sweet corn, to reduce soil erosion and improve soil tilth and fertility (10).

Fresh market sweet corn is planted in relatively small blocks, usually less than 5 acres, as successive plantings spaced temporally to provide a continuous supply of peak quality ears for retail or wholesale outlets. In contrast, the processing acreage is planted in larger rotated fields, usually greater than 30 acres and ranging up to 120 acres (3). Also, much of the early processing acreage on the Lower Shore is double-cropped with other crops, such as soybeans or pickling cucumbers after sweet corn (3, 14) Fresh market sweet corn is harvested 8-21 days after silking, whereas processing corn is harvested 5-7 days later when the ears are more mature. This is important with respect to insect infestations because processing corn stays in the field longer and is more susceptible to ear invasion after the last silk sprays are applied (3).

New processing and fresh market sweet corn hybrids genetically engineered with the *Bacillus thuringiensis* (Bt) gene are being planted on an increasing number of acres each year in Maryland. 3,500 acres of processing Bt sweet corn were harvested in Maryland and Delaware in 1998 (13). These varieties offer high levels of suppression of the major ear-invading pests, particularly early in the growing season, and typically require fewer insecticide sprays (3). However, some insect pests considered minor under previous management practices are becoming increasingly important in Bt sweet corn (3, 7).

Insect Pests

Major Insect Pests in Maryland

The most important pests in sweet corn are those which invade and damage corn ears, primarily European corn borer, corn earworm, and fall armyworm (13, 15). Another important early season pest is the black cutworm, though cutworm infestations tend to be more sporadic than the ear-invading pests. The corn flea beetle can be a problem on some varieties, as a vector of Stewart's bacterial wilt disease early in the season (5).

Ear-Damaging Pests: European corn borer, corn earworm, and fall armyworm

Pests that invade the ear are the most important consideration in sweet corn pest management, since very little damage can be tolerated (15). Most processors can accept no more than 5% of ears with severe damage at the tip and no more than 1% of ears with side-kernel damage before the grading of corn is affected. Severe tip damage is defined as having about an inch of the tip affected. Up to 20% of ears with very minor tip injury (0.25 inch or less) are acceptable to most processors. In all cases the amount of damage accepted depends on the sweet corn variety and the needs of the customer (7). Damage tolerance is generally much lower for fresh market sweet corn (16). European corn borer, corn earworm and fall armyworm are the major ear-invading pests in Maryland (17) and are the focus of IPM programs (15). Treatment recommendations are based on larvae present during whorl and tasselling stages, before larvae invade the ears, and on blacklight trap and pheromone trap catches of adults (17).

European corn borer (*Ostinia nubilalis*)

Damage and Life Cycle

The European corn borer is a serious pest of sweet corn in Maryland. Female moths lay their eggs on the underside of corn leaves from mid-May to early June. Eggs hatch in 3 to 7 days, depending upon temperature. The emerging larvae feed on leaves within the inner whorl of the plant. Larvae damage the whorls, which may affect yields for certain varieties, depending on the timing of the damage (17). During tassel development, larvae tunnel into the stalk, where extensive tunneling sometimes causes breakage. Eventually, larvae outgrow the stalk and move to the developing ear, where they may feed on the silks. Larvae enter the ear via the silks, or from the shanks or side by burrowing through plant tissues. They feed on kernels throughout the cob, causing extensive damage to the ear and reducing marketable yields (15). European corn borer generally has 2 to 3 generations in Maryland (18). It overwinters as a larva in its burrow in the sweet corn stalk or in the stem of a different host plant. Larvae pupate in late April or May, and adults emerge after 2 weeks to continue the next cycle (10).

Frequency of Occurrence

European corn borer is present and affects sweet corn yields every year; however, the percent of ears

damaged and the timing of the damage can fluctuate from year to year and from region to region (17). According to blacklight trap monitoring of adults throughout the state over the past 26 years, the middle Eastern Shore region has the highest average moth activity while the Western part of the state has the lowest. Moth populations can fluctuate considerably annually as well (19). Annual fluctuations in moth populations affect insecticide applications for European corn borer (3).

Corn earworm (*Helicoverpa zea*)

Damage and Life Cycle

Corn earworm is the most destructive pest of sweet corn (16). In the mid-Atlantic, pupae overwinter in the soil, but only survive in areas where the frost line is less than an inch below the soil surface. Surviving moths emerge and mate, and females deposit eggs on sweet corn foliage. The early-season larvae that hatch from these eggs may feed on the whorls or undeveloped tassels, but this feeding rarely affects corn production or quality. Adult corn earworms are highly mobile, and moth populations invade the Mid-Atlantic region from the south by mid-summer. Migrant females lay eggs singly on fresh corn silks during July and August (10). These larvae hatch in 3 to 5 days and begin feeding on the silks, working their way into the ear, where they continue feeding on kernels. Corn earworm damage is usually limited to the tip of the ear. Larvae feed and develop for 10 to 21 days, then cut through the husk as they exit the ear. They drop to the soil, where they pupate for about 14 days, after which adults emerge to begin the next generation (16).

Frequency of Occurrence

The severity of winter temperatures and the amount of snowfall greatly influence the overwintering range of corn earworm from year to year (10); however, the early-season larvae produced from late June through early July have little economic effect on the crop (3, 16). Adults produced from this first generation plus those migrating from southern states produce the larval generations which invade the ear. The timing and magnitude of these summer broods vary considerably from year to year and from region to region, and are influenced by winter and spring weather conditions (16). According to blacklight trap monitoring of adults throughout the state over the past 26 years, the lower and middle Eastern Shore regions have the highest average moth activity while the western part of the state has the lowest (19). The number of moths present each year affects management decisions, which are based on thresholds (17).

Fall armyworm (*Spodoptera frugiperda*)

Damage and Life Cycle

The fall armyworm overwinters in Florida and the Gulf Coast. Each year, adult moths migrate into the Mid-Atlantic region, usually in early July. Each female moth can produce about 1,000 eggs. Eggs are deposited in groups of 50 to 200 on the underside of corn leaves. Larvae feed gregariously in the whorl

when young, then disperse as they grow (16). Plants can generally compensate for feeding damage in the whorl stage, although extensive feeding during the early whorl stage may stunt the corn and reduce yields (10). Larvae also feed on undeveloped tassels. Larvae feed and develop for 2 to 3 weeks, then pupate in the soil. A new brood of moths emerges within 2 weeks to continue the life cycle (16). There are 2 or 3 generations per season in Maryland. Late in the season, when whorls are not available, larvae may enter ears through the silk tube and feed on kernels, causing severe damage to the ear (10). Fall armyworm becomes such a problem late in the season that it is a limiting factor in the production of late season sweet corn maturing after August 21 (13).

Frequency of Occurrence

Fall armyworm is considered a sporadic but important pest throughout the Northeast. It moves into the Mid-Atlantic region from the south, and the timing of its arrival is dependent on weather patterns. Also, moths are generally more numerous along coastal regions. A cold, wet spring in the south can promote fall armyworm survival (10). Normally, fall armyworm starts to cause economic damage in late July and then infestations steadily increase through the remainder of the growing season, however, moths can arrive as early as late June, at which time they lay eggs on whorl stage corn (3). The timing of moth arrival as well as the population level will influence the number of insecticide applications (3, 7).

IPM Program for Ear-Damaging Pests

Field scouting for larvae and monitoring of adults with blacklight traps and pheromone traps are used to maximize effectiveness of control strategies against European corn borer, corn earworm and fall armyworm (15). Trap catches of European corn borer and fall armyworm give a good indication of the level and timing of larval infestation of whorls. Whorl-infesting larvae generally have little effect on overall yield for most varieties, since the plants can compensate for damage incurred at this stage (17), however, they can cause significant damage when populations are high (7). The early tassel stage is the most effective time to apply insecticide for control for European corn borer and fall armyworm, since it prevents worms from migrating to the ears (9, 10). Treatment is applied to most varieties of fresh market corn if over 30% of whorl plants harbor live European corn borer and/or fall armyworm larvae. Some early season varieties are more susceptible to damage and are treated if larval infestation exceeds 15% of whorl plants. A single treatment directed at the whorls usually provides sufficient control. During tasseling, the stage of corn earworm larvae present in fresh market sweet corn will determine whether treatment is applied. If late instar larvae are found on green tassels, they will soon leave the plant to pupate in the soil, without causing damage to the ear. However, if high numbers of young larvae are present on more than 15% of emerging tassels, an insecticide treatment is applied. Treatment is also applied to fresh market sweet corn if more than 15% of tassels are infested with European corn borer and/or fall armyworm. Treatment decisions for processed sweet corn during the whorl and tassel stages are based on number of infested plants with light, moderate, or heavy European corn borer feeding damage (17).

Management decisions during the silking stage for European corn borer and corn earworm are made

primarily based on blacklight and pheromone trap counts of adults. The Maryland Department of Agriculture uses a network of traps to monitor these pests statewide during the silking stage. Growers have access to this information via "hotlines," and can use it to make control decisions. For fall armyworm, the level of activity during whorl and tassel stages of other plantings on the same farm give a good indication of the potential for ear infestation of nearby silking corn (17). For processed sweet corn, fields are scouted during silking to determine the levels of control achieved by chemical treatments (7). Direct sampling of ears during silking to determine the percentage of ears damaged is the most accurate way to decide if further control measures are prudent; however, a high level of adult activity, as determined by pheromone trap catches, may indicate the need for fixed treatment schedules and eliminate the need for direct sampling (7, 17).

Chemical Controls for Ear-Damaging Pests:

Treatment regimes in Maryland are directed against this important pest complex (3). Timing of insecticide applications and delivery of the chemical to the target site are the keys to effective management of ear-invading pests (15). For most effective control, insecticides are applied during the whorl stage for first generation European corn borer and fall armyworm (10) and during tasseling, while larvae of all three species are dispersing (17). Lambda-cyhalothrin (Warrior 2.56-3.84 fl oz 1E/A) is the most frequently used chemical insecticide in sweet corn (3, 13, 20). Warrior is applied at rates as low as 2 fl oz 1E/A early in the year for European corn borer and corn earworm control when population pressure is low. When populations are high, and later in the season for fall armyworm control, the highest labeled rates are often used. Growers utilize the full range of labeled rates depending on the populations of pests present (7).

Timing and number of applications

The timing and total number of insecticide applications can vary considerably from year to year, as influenced by the timing and level of infestation.

European corn borer -- Insecticide sprays can be eliminated for the first 40% of the processing acreage during a low infestation year, whereas 2 to 3 sprays are required for the early to late acreage during high infestation years (3, 7). Processed corn is typically sprayed with insecticides 3 to 4 times during the season, not just for European corn borer, but for all insect control. Very rarely, in years when insect populations are unusually low, 1 to 2 sprays may be sufficient (7).

Corn earworm -- On processing corn, usually the first 25% of the acreage does not require treatment for corn earworm, and 1 to 3 properly timed applications will prevent economic ear damage on the rest of the acreage during years when corn earworm populations are low. In high infestation years, the following treatment regimes may be necessary: one application on the first 25% of acreage, 2 to 3 applications on the next 50% of the acreage, and 4-6 applications on the last 25% of acreage (3).

Fall armyworm -- During years with early flight activity, more than 50% of whorl-stage corn may be treated 1 or 2 times specifically for fall armyworm and more frequent applications may be needed later in the season. In years when moth migration occurs later, damage still occurs, though fewer acres are

treated (7).

Insecticide Use

• Fresh Market

Lambda-cyhalothrin accounts for 80%-85% of chemical treatments directed against ear-infesting pests from whorl through silking stages for fresh market sweet corn (3, 20). Permethrin (6.4-12.8 fl oz Ambush 2EC/A or 4-8 fl oz Pounce 3.2EC/A) is next in popularity (about 10% of acres) followed by esfenvalerate (Asana XL 5.8-9.6 fl oz 0.66EC/A) (about 5% of acres). Permethrin has provided better European corn borer control than esfenvalerate, based on growers' experience and on research results (20). Methomyl (Lannate 1.5 pt LV/A) is used to a lesser extent in Maryland, since it is more toxic and more expensive than some alternatives and offers less consistent control of European corn borer than the pyrethroids (7, 13, 20). Methomyl is used on about 10% of the acreage of late planted sweet corn when fall armyworm is present in the silk stage. It is either alternated or combined with a pyrethroid (20). Two to three foliar spray applications of lambda-cyhalothrin and thiodicarb (Larvin 20-30 fl oz 3.2F/A) with high-spray gallonage (50 to 75 gallons of water per acre) are used to get effective control of fall armyworm in the whorl stage for fresh market sweet corn (9, 13, 20). Thiodicarb is only used against corn earworm in silk stage corn if fall armyworm is also present (13, 20). Fresh market growers typically use 4 to 7 insecticide applications per crop season, depending on infestation levels as determined by scouting and monitoring practices (7).

• Processing

Processing sweet corn is treated less frequently than fresh market sweet corn, since processing corn can tolerate higher levels of feeding damage (13). Growers of processing sweet corn typically use an average of 3 to 4 insecticide applications seasonally, with 4 to 6 applications typical for late-planted sweet corn (7). Lambda-cyhalothrin is the primary insecticide used by processors for control of ear-infesting lepidopteran pests. It is used on about 95% of the acreage. Lambda-cyhalothrin may be combined with methomyl instead of thiodicarb for late season fall armyworm control in processing sweet corn (7, 20) since restrictions on thiodicarb prohibit its use in processing sweet corn (9). Growers have used permethrin on the remaining acres treated, accounting for about 5% in the past few years (20).

Additional chemical controls which are used rarely in Maryland against these ear invading pests are (7, 9):

• For European corn borer and fall armyworm only:

- diazinon (7-14 lb 14G/A) [Whorl application only (20).]

- *Bacillus thuringiensis* var. *kurstaki* (DiPel 1.5-2 pt ES/A applied over whorls using conventional ground or center pivot irrigation systems or DiPel 5-10 lb 10G/A by ground or by aircraft (9).) [Few growers use this product, since efficacy of granular whorl application is greatly reduced with rainfall (7).]

- **For European corn borer only:**

- methyl parathion (Penncap-M 2-4 pt 2FM/A) [Growers do not use Penncap-M during tasseling and pollen shed as it will seriously reduce bee populations (13). Used only when European corn borer pressure is very high, or where another chemical control has failed (7).]
- chlorpyrifos (Lorsban 6-8 oz 15G/1,000 ft of row applied at planting) [Less than 10% of fresh market acreage is treated (3).]

Alternative Controls for Ear-Damaging Pests

No cultural or biological control strategies are used against ear-damaging pests in Maryland (13).

Natural Controls

There are several natural predators and parasites of the European corn borer in Maryland, though these generally do not keep populations below economic injury levels (10). Maryland fresh market growers don't scout for parasitoids or predators or use such information for decision-making in European corn borer control (3). Processors do consider the level of parasitism when making control decisions (7).

Transgenic Bt Sweet Corn

In 1998, Maryland and Delaware growers harvested about 3,500 acres of processed sweet corn genetically engineered with the *Bacillus thuringiensis* (Bt) gene (13). A limited amount of fresh market Bt sweet corn was planted on a trial basis (3). These new genetically engineered varieties offer effective control of ear-invading lepidopteran pests, and should reduce the need for insecticide treatments. However, under lower insecticide use regimes, some minor pests typically controlled by materials applied for ear pests may require treatment in Bt corn to prevent economic infestations. For example, dusky sap beetle requires chemical control as it is not affected by the Bt gene (3, 21).

Bt varieties give nearly 100% control of European corn borer, and at low to moderate population pressure also suppress corn earworm and fall armyworm. Early in the season, the level of control achieved is typically sufficient to prevent economic damage to the ear in processing and most fresh market fields. However, under high pressure late in the growing season, some corn earworm and many fall armyworm larvae survive Bt expression and invade the ear tip (3). Although these larvae cause relatively little kernel damage, they still pose an ear quality problem for most fresh market farmers and many processors. Thus, 1 to 4 foliar insecticide treatments are typically necessary to control these survivors and also control non-target pests such as dusky sap beetles (3, 7). The products typically used on Bt sweet corn are thiodicarb (Larvin 20-30 fl oz 3.2F/A), methomyl (Lannate 1.5 pt LV/A), and

lambda-cyhalothrin (Warrior 2.56-3.84 fl oz 1E/A). Late plantings of Bt corn should be avoided, since population pressure of fall armyworm late in the season results in insufficient pest suppression and can dramatically affect sweet corn yield and quality (7).

Pest mortality tends to be very high in Bt sweet corn, and the selective pressure placed on pest populations may speed the rate of pest adaptation to these crops. Researchers have been working closely with EPA and seed producers to develop resistance management strategies for genetically altered crops. Research models indicate that by maintaining patches of susceptible, non-engineered crops within or near a transgenic crop, growers can greatly slow the development of resistance in the pest population by providing Bt-susceptible mates (22, 23). However, no refuge of non-Bt sweet corn is required with the use of Bt sweet corn. Instead, the nearby non-Bt field corn acreage and other host plants are expected to provide enough susceptible insects to dilute resistance. In addition, growers are required to destroy the remaining stalks of Bt sweet corn within 30 days after harvest to prevent any surviving larvae from reaching pupation. This practice, plus the fact that a portion of the Bt sweet corn acreage will receive supplemental insecticides, will ensure the high dose strategy and reduce the risks of resistance development (3). Also, seed companies require growers using Bt sweet corn varieties to scout fields for the development of resistant European corn borer and corn earworm individuals and to use IPM strategies for the management of non-target pests (21), although at this time there are no specific guidelines as to what constitutes sufficient scouting or IPM strategies (7).

The Bt hybrids are an excellent new pest management option for fresh market growers and processors, but will require careful and intensive management to assure adequate economical pest control and to avoid the development of resistant insect pest populations (7).

Other Major Insect Pests in Maryland

Cutworms

Damage and Life Cycle

Cutworms are a sporadic but potentially serious early-season pest of sweet corn in the Northeast (10). Black cutworm (*Agrotis ipsilon*), the most damaging cutworm species in sweet corn, also feeds on a broad range of other vegetable crops. The life cycle is not completely known for this pest in the Mid-Atlantic states. It may overwinter as a mature larva or a pupa, or perhaps adults are carried on the wind from the South. Females deposit eggs on debris or dense weeds in moist soil during April and early May. Eggs hatch in 7 to 14 days, and young larvae feed on the leaves of young corn plants. Larger larvae bore into plant stems or cut stems at or below ground level. Larvae develop through 7 instars, feeding for 4 or 5 weeks before pupating in the soil. Two more generations appear in the summer, but are not damaging to corn (18).

Frequency of Occurrence

Cutworms are a sporadic but serious pest of sweet corn (20). In many cases, infestations are lower on

sweet corn than field corn, because most fields are conventionally-tilled and rotated with other crops, and thus do not possess the field characteristics that favor cutworms (3). However, sweet corn growers who use no till or minimum tillage practices, or those who rotate with small grain rather than vegetable crops, typically have more cutworm problems (11). There is considerable variation in this pest regionally (13). According to blacklight trap monitoring of adults throughout the state over the past 26 years, Baltimore and Harford counties have the highest average moth activity while the lower central part of the state has the lowest. Moth populations can fluctuate considerably from year to year as well (19).

IPM Program

Sweet corn fields in Maryland are scouted for cutworm damage from May through early June, and blacklight and pheromone traps are used to monitor adult populations (18). Treatment is recommended at the 1 to 2 leaf stage if more than 10% of plants show larval feeding damage. Corn in the 3 to 4 leaf stage is treated if 5% of plants have been cut and 4 or more cutworms are found per 100 plants. However, stand count has an influence on management decisions, since it will affect the amount of damage that can be tolerated (10). Generally, growers only treat areas that have a history of cutworm infestation, or when a problem occurs (7, 13).

Chemical Controls

Preventive treatments applied before or during planting are generally not used, since cutworm problems are difficult to predict and effective rescue treatments are available (15). Rescue treatments are typically applied to less than 5% of acreage annually, usually to minimum tillage fields or those following small grain cover crops (20). Chemical applications for cutworms are applied in the evening to achieve maximum control (11). The primary insecticides used in Maryland are lambda-cyhalothrin (Warrior 2.0-2.75 fl oz 1E/A) and permethrin (4-6 fl oz Ambush 2EC/A or 3-4 fl oz Pounce 3.2EC/A). (Note that both of these are used at low or below label rates.) Both chemicals are effective and market price generally determines which one is used (7). There are no differences in insecticide usage between fresh market and processed sweet corn for control of cutworms (7, 13).

Alternative Controls

Rotary hoeing may be used to control minor infestations (15), though very few growers do this (13).

No biological control strategies are used to control this pest in Maryland (13).

Corn flea beetle (*Chaetocnema publicaria*)

Damage and Life Cycle

Corn flea beetles overwinter as adults in litter and debris around fields and feed on weeds until early corn seedlings become available in May or June. Eggs are scattered in the soil at the base of young corn plants. Larvae hatch in 10 to 14 days and feed on the roots for 3 to 4 weeks before tunneling into the soil to pupate. Three or more generations are completed annually (10). Direct damage due to adult feeding

on leaves is insignificant except in the most severe infestations of slow-growing sweet corn varieties; however, feeding can transmit Stewart's bacterial wilt (also known as bacterial wilt disease) to susceptible varieties (18). Some of the processing varieties and many of the fresh market varieties are susceptible to Stewart's wilt (7). The disease appears in late May and becomes progressively worse throughout the season (18). Incidence of bacterial wilt on sweet corn has been shown to be directly related to the size of corn flea beetle populations. Control of the flea beetle is the primary means of preventing the disease (10).

Frequency of Occurrence

In recent years corn flea beetle has become an increasingly important pest on the Eastern Shore of Maryland, where annual populations justify preventive control of the beetle to discourage the spread of Stewart's bacterial wilt (7). The corn flea beetle is not a significant pest of sweet corn west of the Chesapeake Bay, where populations rarely reach economic levels (11). Differences in flea beetle populations east and west of the Chesapeake Bay greatly influence management strategies in these 2 areas (7, 11). The most severe infestations occur when a mild winter is followed by a cool spring (18).

IPM Program

Flea beetles are an important component of IPM programs on the Eastern Shore (7). Scouting for beetles throughout the fields during the spike stage on calm sunny days can give an indication of the level of beetle activity (18). Treatment is recommended if 5% of plants or more are infested with beetles (10). Fields are scouted following preventive insecticide application, since sometimes systemics provide insufficient control when beetle pressure is high (7).

Chemical Controls

- **Eastern Shore**

On the Eastern Shore, preventive systemic soil insecticides are applied at seeding to control corn flea beetle on about 95% of fresh market and about 90% of processing acreage (7, 24).

Carbofuran (Furadan 2.5 fl oz 4F/1,000 ft of row in the seed furrow at planting) is the most commonly used product on the Eastern Shore, followed by terbufos (Counter 8 oz 15G/1,000 ft of row in the seed furrow or 8-16 oz 15G/1,000 ft of row if banded). Esfenvalerate (Asana XL 5.8-9.6 fl oz 0.66EC/A) is used to a lesser extent (7, 13). Fields are routinely scouted to determine the efficacy of preventive insecticides. Some years, an additional single foliar insecticide application is necessary on some fresh market fields when beetle populations are high. For example, in 1999, a foliar application was made on about 40% of early fresh market sweet corn for flea beetle control. The most commonly used foliar insecticides are lambda-cyhalothrin (Warrior 2.56-3.84 fl oz 1E/A) and permethrin (6.4-12.8 fl oz Ambush 2EC/A or 4-8 fl oz Pounce 3.2EC/A). Both products are effective, so product selection is driven by price. Processing sweet corn rarely requires foliar insecticides for control of flea beetle (7).

- **West of the Chesapeake Bay**

Growers west of the Chesapeake Bay very rarely treat specifically for flea beetle control. The

widespread use of Stewart's wilt resistant varieties combined with lower populations of flea beetles make chemical controls unnecessary (11).

Pesticide Use Issues

On the Eastern Shore, the loss of systemic soil insecticides for control of flea beetle would result in a significant increase in the number of foliar applications. Also, these products give a broad spectrum of control with a single economical application, suppressing populations of soil pests such as wireworms and grubs in addition to controlling flea beetles. Flea beetle control is critical to prevent outbreaks of bacterial wilt, which in extreme cases have resulted in up to 80% yield loss in some fields (7). Typical annual yield loss from bacterial wilt in fresh market sweet corn on the Eastern Shore is about 5% of acreage (24).

Alternative Controls

Most processing varieties show some level of resistance to bacterial wilt (5). Where possible, growers use cultivars resistant to bacterial wilt disease (9), especially for early plantings during cool springs following mild winters (13). However, market demands often require that growers choose susceptible varieties with other characteristics over varieties with bacterial wilt resistance (7).

No biological control strategies are used to control this pest in Maryland (13).

Dusky sap beetle (*Carpophilus lugubris*)

Damage and Life Cycle

Adult and pupal stages of the dusky sap beetle overwinter in corn refuse in the soil or in protected places above ground. Adults are first noticed at about the time tassels appear on the earliest sweet corn. They invade corn borer tunnels and feed on frass. They also feed on the pollen as it ripens on the tassels and later as it lodges in the leaf axils. Mating and egg laying begin when the females are 5 to 6 days old. Eggs are deposited on worm frass and wet accumulations of pollen, which are suitable for larval development if these sites remain moist for 10 to 14 days. Sap beetle activity increases as the corn matures, and adults usually invade the ear when the silks begin to turn brown. The majority of eggs are laid on worm frass at the ear tip or scattered through the silk strands. As the larvae hatch, they move deeper into the ear where they penetrate and hollow out the developing kernels. Full-grown larvae leave the ear and burrow into the soil to pupate. At least 2 or 3 overlapping generations occur each year in the mid-Atlantic region (16).

Frequency of Occurrence

Dusky sap beetle is a sporadic but important pest of sweet corn (7, 15). Previously, this pest was controlled by chemical applications made for key pests. It is an emerging problem in Bt sweet corn where these chemical applications have been reduced (3, 7). Winter survival is an important factor in determining the spring population. Many overwintering adults are killed by freezing temperatures during December and January. Sap beetle problems are most severe during late June, July, and into August (7,

25), particularly if corn is damaged by other pests, such as European corn borer or corn earworm. Sap beetle problems are most likely to occur on farms producing a variety of fruit and vegetable crops (10), which includes most of Maryland sweet corn producers (7). The number of beetles present each year affects management decisions, which are based on thresholds (13).

IPM Program

Corn is sampled when fresh green silking is complete and wilted silks are present. The silk area at the tip of 20 primary ears at each of 5 sites per field are inspected to determine the percent of ears infested with adult beetles, eggs, or larvae. Insecticide treatments are applied as needed if more than 10% of the ears are infested with beetle adults, eggs, and/or larvae (5, 7, 10).

Chemical Controls

Sap beetle populations are usually controlled by insecticides applied to treat the major ear-invading insects; however, there are times when densities of these major pests are low, but sap beetle populations are high enough to warrant insecticide treatment. Lambda-cyhalothrin (Warrior 2.56-3.84 fl oz 1E/A) is the first choice of growers, followed by diazinon (2.5 pt 4EC/A or other labeled formulations). Esfenvalerate (Asana XL 5.8-9.6 fl oz 0.66EC/A) and methyl parathion (PennCap-M 2-4 pt 2FM/A) may be used in rare instances (7). Insecticides are applied more frequently to fresh market sweet corn, since less injury can be tolerated than in processing corn (13).

Alternative Controls

Most Maryland growers minimize sap beetle problems by using tight husk varieties with good husk extension (7). Deep tillage in the fall to destroy overwintering stages and use of crop sanitation practices during the growing season minimize alternative food sources and help to reduce the build-up of sap beetle populations on a farm (3).

No biological control strategies are used to control this pest in Maryland (13).

Minor Insect Pests in Maryland

Minor Soil Insect Pests: Seedcorn Maggot, wireworm and white grubs

Seedcorn maggot, wireworms, and white grubs are minor pests of sweet corn, and rarely cause major economic damage in Maryland. These pests are generally controlled by chemical applications directed at important pests such as flea beetles (7).

Seedcorn maggot (*Delia platura*)

Damage and Life Cycle

Seedcorn maggot is a common insect throughout the Northeast (10). Adult flies emerge from

overwintering puparia during spring planting time and females lay eggs just below the surface of the soil. Eggs hatch in 4 to 7 days, and emerging larvae feed on decaying organic matter. Maggots may burrow into the corn seed and consume the germ, preventing germination. Larvae feed for 21 days, then pupate in the soil. There are 4 to 5 generations per season in Maryland (26), but only the first and second generations are a problem, since they coincide with planting times. When damage occurs, it is often extensive, covering much of the field (11).

Frequency of Occurrence

Seedcorn maggot is a rare pest of sweet corn, since insecticide seed treatments are used by nearly all growers (7, 13, 15). Injury is most severe in cool wet springs when germination is delayed. Fields high in crop residue and other organic matter are more susceptible to high levels of infestation (10).

Wireworms

Damage and Life Cycle

Wireworms are the larvae of click beetles (Elateridae). Several species attack corn and a variety of other grasses. Eggs are deposited on host plants in late spring. Larvae infest the soil, hollowing out seeds and pruning roots, making them susceptible to rot. They may also tunnel into or feed on the underground portion of seedling stems, causing wilting, distorted growth, and often plant death. Larvae feed and develop for 3 to 5 years before pupation (10).

Frequency of Occurrence

Wireworms are rarely a problem in sweet corn (15). They are most commonly found in corn fields where the preceding crop was pasture, hay, or sod. They do the most damage during cool, wet springs (10).

White grubs (Scarabidae)

Damage and Life Cycle

The adult scarab beetles which produce white grubs prefer to lay their eggs in fields which have extensive weed growth during mid-summer. Larvae hatch during late-summer and move through the soil where they feed on the roots of sweet corn, causing wilting, stunting and eventually death of young plants if infestations are heavy. Damage is usually localized. White grubs feed and develop as larvae for 1 to 4 years, depending upon the species (10).

Frequency of Occurrence

White grubs are rarely a problem in sweet corn (15). Like wireworms, white grubs are most commonly found in corn fields where the preceding crop was sod or other grasses (10). They thrive best in cool,

wet soils (15).

IPM Program for minor soil pests

Seedcorn maggot, wireworms, and white grubs are not a major focus of IPM programs in Maryland (11, 13). Feeding by all of these pests can result in wilted or stunted plants that often die. In addition, reduced germination is characteristic of seedcorn maggot and wireworms. Damage from grubs and wireworms tends to be localized within a field, while seedcorn maggot damage can cover most of a field (10). These symptoms can be recognized by an IPM scout. In areas where plants have failed to emerge, sampling may be done to determine the pest species present (17). Since damage occurs in the early growth stages, rescue treatments are ineffective for these pests (13). If damage is extensive enough to warrant replanting, seed treatment or soil insecticide is applied to prevent reinfestation (17).

Wireworm infestation levels of a field can be determined prior to planting (9), but few growers sample fields routinely. Growers may sample fields where preventive insecticide treatments are not used if wireworms have been a problem in the past, to determine if preventive treatment is warranted (11).

Grubs uncovered in the soil during spring tillage and planting operations are the best indication of a potential infestation. It is important to determine the species of grub, since not all white grubs cause significant damage to sweet corn. Annual white grubs and Japanese beetle grubs rarely cause economic damage unless the corn is planted extremely early (10). Most of the processing acres on the Eastern shore include grubs in scouting programs (7)

Chemical controls for minor soil pests

Because damage is inflicted early in growth stages, seed treatments and soil systemic insecticides are the only chemical treatments applied for this pest complex. Foliar rescue treatments are not used for these pests (10).

- **Seed treatments**

Insecticide seed treatments are effective and inexpensive (7, 10, 15) and are used by nearly all growers (7, 11, 13). A diazinon-lindane combination, such as Agrox D-L Plus (also contains captan), is most commonly used (11). These products are very effective against seedcorn maggot and deter feeding by wireworms and white grubs (7).

- **Preventive soil insecticides**

Soil insecticides are applied either in the spring or fall when the soil temperature at the 6-inch depth is at least 50° F (10° C) and soil moisture is equivalent to that desired for planting. Frequently, the insecticide is applied immediately before planting. When early spring planting is contemplated, the fall treatment is preferred (9).

On the Eastern Shore, preventive systemic soil insecticides are applied at seeding to control corn flea beetle on about 95% of fresh market and about 90% of processing acreage (7, 24). These products will control, or at least suppress, populations of minor soil pests. Soil treatments directed specifically at seedcorn maggot, wireworms, or white grubs are very rare on the Eastern Shore. Carbofuran (Furadan 2.5 fl oz 4F/1,000 ft of row in the seed furrow at planting) is the most commonly used product on the Eastern Shore, followed by terbufos (Counter 8 oz 15G/1,000 ft of row in the seed furrow or 8-16 oz 15G/1,000 ft of row if banded).

Esfenvalerate (Asana XL 5.8-9.6 fl oz 0.66EC/A) is used to a lesser extent (7, 13).

Preventive soil insecticides are used on fewer than 30% of fresh market acres west of the Chesapeake Bay (12), where flea beetles are less of a problem. These products are typically used for fields in low-lying, wet, cool areas bordering a wood, or where wireworms have been a problem in previous years. Terbufos (Counter 8 oz 15G/1,000 ft of row in seed furrow), tefluthrin (Force 4-5 oz 3G/1,000 ft of row in furrow), and chlorpyrifos (Lorsban 8 oz 15G/1,000 ft of row in furrow or 4 pt 4EC/A preplant broadcast incorporated) are the primary chemical controls used west of the Chesapeake Bay (11).

Alternative controls for minor soil pests

A variety of cultural control measures are effective against these pests. Late plantings during cool springs and shallow placement of seeds may speed germination times and reduce injury levels (10). Delayed planting also may starve soil pests and increase natural control from bird predation (15). However, late plantings are not economically feasible for most growers of fresh market and processing sweet corn in Maryland (7). Crop rotation with less susceptible crops and late-summer plowing may be used to help reduce white grub populations (10). Growers also may avoid planting sweet corn following alfalfa, sod, or pasture, to reduce the risk of wireworms (15). Fields with cover crops or those high in organic matter may be plowed in early spring to reduce the potential for seedcorn maggot infestation (10). Overall, these cultural control methods are used to a very limited extent by Maryland growers (12, 13).

No biological control strategies are used to control these pests in Maryland (13).

Additional Minor Insect Pests

True armyworm (*Pseudaletia unipuncta*)

Damage and Life Cycle

True armyworms overwinter in soil or debris as partially developed larvae (27), completing their development in early spring and then pupating. Moths emerge from late April to early May and deposit eggs on corn and other grasses. Larvae feed on seedling and early whorl stage corn during late May and June. Feeding results in characteristically ragged leaves. Later plantings of sweet corn may also be

damaged by a second generation of larvae (18). This pest typically produces 3 generations a year (27).

Frequency of Occurrence

True armyworm is a sporadic and minor pest of sweet corn (15). It is unusual for armyworms to occur at levels high enough to justify treatment. Infestations only occur in fields bordering small grains, which often harbor this pest (7, 13).

IPM Program

Field edges bordering small grains are routinely scouted for armyworm infestations. Occasionally, edges of sweet corn fields and small grain fields are treated to prevent migration of armyworms into sweet corn (7). The need for treatment is based on the percent and severity of damaged plants and the average larval size (18).

Chemical Controls

Chemical controls are rarely needed for true armyworm, and generally can be limited to edges of a field bordering small grains, to prevent infestation of sweet corn. A very low percentage of acreage is treated (7, 12). Esfenvalerate (Asana XL 5.8-9.6 fl oz 0.66EC/A) and cyfluthrin (Baythroid 1.6-2.8 oz 2E/A) are the most commonly used chemical controls in Maryland (13).

Alternative Controls

Controlling grassy weeds can reduce the risk of armyworm damage. For minor infestations, rotary hoeing is a sufficient control measure (15).

No biological control strategies are used to control this pest in Maryland (13).

Corn leaf aphid (*Rhopalosiphum maidis*)

Damage and Life Cycle

Corn leaf aphids overwinter on small grains as either eggs or females that give birth during early spring. Wingless females produce offspring without mating for numerous generations. During late May and June, winged aphids migrate to corn and wild grasses where they spend the summer. Aphids injure sweet corn by removing plant sap with their needle-like mouthparts (10). They also excrete a sugary liquid, called honeydew, which can coat tassels and interfere with pollen shed as well as causing cosmetic damage to the ears (7, 10). Corn leaf aphids reproduce rapidly, and populations can increase dramatically in a very short time. As aphid numbers rise, colonies usually begin to appear on the leaves, tassels, and between the husk leaves on the ear (10).

Corn leaf aphid is one of several species of aphids that transmit maize dwarf mosaic virus to sweet corn (10), however, this is only a potential problem for non-resistant varieties planted after July 1 in Maryland (9). The virus can be spread to sweet corn by aphids from neighboring infected grasses,

particularly johnsongrass (*Sorghum halepense*) (28). The most important management strategies for maize dwarf mosaic virus are the use of virus-tolerant varieties (14) and control of weeds that are potential host plants for the virus, especially johnsongrass (10).

Frequency of Occurrence

Aphids are rarely a problem because infestations either build up too late to cause significant damage or they are controlled by natural enemies (10).

IPM Program

Few growers include corn leaf aphid in their IPM programs (13).

Chemical Controls

Growers very seldom treat specifically for corn leaf aphids (3, 13). Management practices for controlling European corn borer and corn earworm generally prevent populations from reaching economic levels (15). Prior to the use of lambda-cyhalothrin for the control of ear-invading larvae, aphids were an important pest of fresh market corn, due to cosmetic damage to husks. Aphids are not a problem on processing sweet corn. In rare instances when lambda-cyhalothrin is not used to control larval ear pests, and treatment specifically for aphids is considered, methomyl (Lannate 1-1.5 pt LV/A) or endosulfan (Thiodan 1 pt 3EC/A) are used at low or below labeled rates (7).

Diseases

Infectious diseases of sweet corn are caused by fungi, bacteria, viruses, and nematodes, and some are vectored by insects. Successful and cost-effective disease management requires accurate identification of pathogens and timely application of control measures (10). Some diseases are controlled mainly by management of insect vectors, while for others, cultural or chemical controls may be necessary, at least in some years (9).

Bacterial Diseases

The most important bacterial disease in Maryland is Stewart's bacterial wilt, which is seen to a greater or lesser extent every year. Bacterial stalk rot also occurs, but is rare and limited to fields under irrigation or those watered from streams. Unlike Stewart's wilt, stalk rot rarely results in important economic losses in Maryland (31).

Stewart's bacterial wilt

Life Cycle and Damage

Erwinia stewartii, the bacterium that causes Stewart's wilt, or bacterial wilt, overwinters in the digestive tract of flea beetles and is transmitted by beetles feeding on the leaves. Although flea beetles are not the only insects known to vector this disease to sweet corn, transmission by other insects is not of economic importance. Epidemics of bacterial wilt may follow warm winters, which favor flea beetle survival. As many as 40% of overwintering flea beetles carry the bacterium in spring, and this percentage climbs as the season progresses (11). When young plants are infected, brown discoloration, and sometimes cavities, form in the center of the stem. These plants may die. In older plants, infection results in streaked leaves and growth may be stunted (28).

Frequency of Occurrence

Bacterial wilt is an important disease throughout the Eastern United States, but its occurrence and severity depend on the winter weather conditions and the susceptibility of the sweet corn variety. The extent of bacterial wilt damage depends on the growth stage of corn infected, the bacterial strain, host susceptibility, and nutritional factors. Younger plants are most severely affected (10). In Maryland, some bacterial wilt damage is seen annually on susceptible varieties (31). Bacterial wilt infection rate is typically about 10% in fresh market sweet corn and 1% in processing sweet corn, however, the disease is not severe and generally causes no more than 5% yield loss when it occurs (24). In extreme cases where susceptible varieties are used and other controls have failed, up to 80% yield loss from bacterial wilt has been reported (7).

Management

Use of bacterial wilt resistant varieties is an important management strategy employed by most growers of processing and fresh market sweet corn, although the level of resistance varies among varieties (24). Also, lower quality and yield of many resistant varieties combined with competition and other market factors compels many growers on the Eastern Shore to select more susceptible varieties (7). Management of bacterial wilt is achieved by control of the flea beetle vector. A winter temperature index is used to estimate flea beetle survival (10), though they typically are successful at overwintering in the Mid-Atlantic region (31). 90 to 95% of growers on the Eastern Shore treat preventively at seeding to control flea beetle populations (7, 24). Fields are scouted to determine the effectiveness of treatment. When beetle populations are high, a single foliar rescue treatment is also applied to reduce transmission of bacterial wilt (24). Such foliar treatments are not typically needed every year, but may be applied to as much as 40% of early planted corn on the Eastern Shore during bad years (7).

Chemical Controls

There are no chemical controls that work directly on bacterial-wilt infected plants (9). The disease is managed by chemical control of the flea beetle vector (24).

- **Eastern Shore**

On the Eastern Shore, preventive systemic soil insecticides are applied at seeding to control corn flea beetle on about 95% of fresh market and about 90% of processing acreage (7, 24).

Carbofuran (Furadan 2.5 fl oz 4F/1,000 ft of row in the seed furrow at planting) is the most

commonly used product on the Eastern Shore, followed by terbufos (Counter 8 oz 15G/1,000 ft of row in the seed furrow or 8-16 oz 15G/1,000 ft of row if banded). Esfenvalerate (Asana XL 5.8-9.6 fl oz 0.66EC/A) is used to a lesser extent (7, 13). Fields are routinely scouted to determine the efficacy of preventive insecticides. Some years, an additional single foliar insecticide application is necessary on some fresh market fields when beetle populations are high. For example, in 1999, a foliar application was made on about 40% of early fresh market sweet corn for flea beetle control. The most commonly used foliar insecticides are lambda-cyhalothrin (Warrior 2.56-3.84 fl oz 1E/A) and permethrin (6.4-12.8 fl oz Ambush 2EC/A or 4-8 fl oz Pounce 3.2EC/A). Both products are effective, so product selection is driven by price. Processing sweet corn rarely requires foliar insecticides for control of flea beetle (7).

- **West of the Chesapeake Bay**

Growers west of the Chesapeake Bay very rarely treat specifically for flea beetle control. The widespread use of Stewart's wilt resistant varieties combined with lower populations of flea beetles make chemical controls unnecessary (11).

Cultural Controls

Most processing varieties show some level of resistance to bacterial wilt (5). Where possible, growers use cultivars resistant to bacterial wilt disease (9), especially for early plantings during cool springs following mild winters (13). However, market demands often require that growers choose susceptible varieties with other characteristics over varieties with bacterial wilt resistance (7).

Viral Diseases

The only sweet corn disease caused by a virus that is of economic importance in Maryland is maize dwarf mosaic virus (10), and it has not been a problem for several years (31).

Maize dwarf mosaic virus

Life Cycle and Damage

Maize dwarf mosaic virus has a large host range, including at least 251 grass species in 79 genera (10). It can be spread by aphids from neighboring infected grasses to sweet corn. The virus overwinters in perennial grasses, and johnsongrass (*Sorghum halepense*) is an important overwintering host (28). The disease is spread by at least 12 species of aphids, and transmission occurs within the first few seconds of feeding (10).

Frequency of Occurrence

Maize dwarf mosaic virus ranges throughout the United States, and is common in the Northeast (10). The virus only occurs in Maryland on sweet corn planted after July 1, because the build up of disease

titer in host weeds becomes sufficient in late summer to overwhelm the genetic resistance of many varieties (14). Very little sweet corn is planted in Maryland after the first of July (5) and the virus occurs on less than 5% of these acres (24).

Management

The most important management strategy for maize dwarf mosaic virus is the use of virus-tolerant varieties. Tolerance is usually adequate to prevent yield loss in the sweet corn varieties developed in the last 20 years. If it weren't for the dwarf mosaic resistant varieties, growers couldn't plant sweet corn after mid-May without significant yield losses (14). Control of weeds that are potential host plants for the virus, especially johnsongrass, is an important management strategy (10). However, aphids living on johnsongrass or other hosts may shift to sweet corn when weeds are killed. Although this is typically not a concern with resistant commercial sweet corn varieties, in extremely dense johnsongrass populations the potential exists for the transmission of a large amount of the viral pathogen into sweet corn which could overwhelm the tolerance mechanisms and cause viral symptoms (14).

Chemical Controls

There are no chemical controls that can kill the virus in an infected plant. Preventing the buildup of the vector aphid populations may help. Often, the control program for European corn borer and corn earworm will keep aphid populations low (15). In any case, insecticides applied after aphid populations have been discovered do not effectively control the spread of the disease, since transmission of the virus occurs during initiation of plant feeding (10). For these reasons, insecticides are rarely applied specifically for the purpose of controlling aphids or maize dwarf mosaic virus (32). Control of johnsongrass and other potential host weeds is an important disease management strategy (10) and is achieved in fresh market or processing sweet corn with a single application of one of the following herbicides (9):

- butylate - 3-6 lbs ai/A (3.75-7.33 pts/acre Sutan+ 6.7EC).
- Metolachlor - 1.5-2 lbs ai/A (1.54- 2.05 pts/acre of Dual II 7.8E). [Only controls seedling johnsongrass (14)].
- alachlor - 1.5-3 lbs ai/A (1.5-3 qts/acre MicroTech or 2.3-4.6 lbs/acre of Partner 65DF). [Only controls seedling johnsongrass (14)].
- glyphosate - 1-2 lbs ai/A (1-2 qts/acre of Roundup Ultra 4SC) [For no-till corn, preplant or preemergence use only. Postharvest application is done every 3 to 5 years on 2 to 5% of acreage (any tillage) to suppress populations of specific major weeds, including horsenettle, johnsongrass, Canada thistle, quackgrass and field bindweed (14).]
- nicosulfuron 0.031 lb ai/A (0.66 oz/acre Accent 75SP) [Newly labeled only for specific varieties of sweet corn for processing in 1999. A single application may be used annually in sweet corn up to 10 inches high, or up to 18 inches if drop nozzles are used. This product will provide

postemergent control johnsongrass, shattercane, and other annual grasses which are potential hosts for maize dwarf mosaic virus (14).]

Fungal Diseases

The only significant fungal diseases in Maryland are common smut, southern corn leaf blight, northern corn leaf blight, common rust, and southern rust (31). Nearly all sweet corn seed comes pre-treated with fungicides from the seed companies (11, 13).

Common smut

Life Cycle and Damage

Common smut (*Ustilago maydis*) is the most frequently occurring disease of sweet corn in Maryland (24). It is easily recognized by large galls that form in the ears, leaves, and tassels of the plant. Galls are silvery-white when formed, but later produce masses of powdery dark brown to black spores. The disease overwinters on top of the soil as teliospores, which develop into airborne basidiospores in the spring. In favorable climatic conditions, these basidiospores can infect susceptible plant tissues which have been damaged by mechanical injury or insect feeding (10).

Frequency of Occurrence

Common smut is a widespread and economically important disease in Maryland, for which there is no chemical control (31). It is most common when weather conditions are hot and dry (11). Common smut results in about 3 to 5% yield loss annually in both processing and fresh market sweet corn (24).

Management

There is a variable range of smut resistance among sweet corn varieties and the more resistant varieties are used as often as possible, particularly for processing (7). Most varieties are at least moderately resistant (24). Early cultivation can reduce infection rates by reducing mechanical damage to corn roots and stems and lowering transmission rates. This is practiced by most growers on the Eastern shore (7), but less so by growers west of the Chesapeake Bay (11). Crop rotation, which is practiced for a variety of reasons, also helps reduce smut transmission to sweet corn (24).

Controlling European corn borer as soon as the tassels appear is said to reduce the risk of smut transition (9), but this strategy doesn't eliminate the disease in Maryland (31). 50 to 75 % of Maryland fresh market sweet corn acres and all processing acres are scouted for insects, and smut damage will be noted (7, 24).

Chemical Controls

There are no fungicides available for control of smut in Maryland sweet corn. Control of European corn

borer during the tassel stage may be helpful in reducing the spread of the disease (31).

Leaf blights

Two important leaf blight diseases occur in Maryland: southern corn leaf blight (*Bipolaris maydis*) and northern corn leaf blight (*Exserohilum turicum*). Both are minimal and sporadic, and their occurrence depends upon the resistance level of the variety used and environmental conditions (31).

Life Cycle and Damage

Leaf blights cause spots or lesions on the leaves. When lesions are numerous, the leaf may die. Spores are the overwintering stage for both fungi. Spores of *Bipolaris* overwinter in infected leaf tissue in crop debris in the field. The spores of *Exserohilum turicum* can survive with or without plant debris. Overwintering spores may be spread by wind to susceptible plants in the spring. Southern corn leaf blight requires 4 or more hours of moist conditions for transmission and spreads quickly during extended periods of moisture when temperatures are between 75°F and 95°F. Infection of northern corn leaf blight requires leaf surfaces to be moist for 5 hours when temperatures are about 70°F. Sporulation for both species occurs under moist conditions when temperatures are favorable (10).

Frequency of Occurrence

Southern corn leaf blight occurs throughout the world (10) and northern corn leaf blight is also widespread (31). Both southern corn leaf blight and northern corn leaf blight are most likely to develop in poorly drained sites or areas adjacent to woods or other wind breaks (10). Southern corn leaf blight and northern corn leaf blight are minimal and sporadic in Maryland (31).

Management

Resistant varieties are available for both blight diseases (10). Fifty to 75 % of Maryland sweet corn acres are scouted for insects, and leaf blight incidence and severity is noted (24). Crop rotation and plowing under of corn stubble are important means of reducing inoculum sources for both species. Fungicide sprays are effective against these diseases but are rarely needed. Growers using susceptible cultivars can monitor weather conditions to determine if the spread of southern corn leaf blight is favored; however, sprays will not be necessary unless sufficient inoculum is present (10). There are no differences in management practices between fresh market and processing sweet corn (31).

Chemical Controls

Chemical control is generally not used for control of blight diseases in Maryland sweet corn (31).

Rusts

Common rust (*Puccinia sorghi*) and Southern rust (*Puccinia polysora*) are the only economically important rust species that occur in Maryland (31).

Life Cycle and Damage:

Spores of both rust fungi overwinter in the Southwest and are reintroduced to our region each year, carried on the wind. All exposed plant tissues are susceptible to infection, but leaves are most often affected. Brown spots occur on both sides of the leaves and darken as they age. In severe cases the leaf may die. The worst infestations may lead to economic losses due to smaller ear production and cosmetic injury from pustule development on the ears (10).

Frequency of Occurrence:

Common rust is widespread and occurs throughout Maryland. Its severity can fluctuate considerably from year to year, but it is most severe during warm, humid weather. Southern rust is limited to southern Maryland (31). Significant rust damage occurs an average of 1 out every 10 years (24).

Management:

Resistant cultivars are used by more than 80% of fresh market and processing sweet corn growers (7, 31). They are particularly important to growers making successive plantings of fresh market corn in the same field (31). Fields are monitored for rust during the early growth stages. If infection occurs prior to the whorl stage, a fungicide is applied (9). One pustule per leaf on 80% of the leaves prior to tasseling is the threshold for moderately susceptible fresh market varieties. A lower threshold is used for highly susceptible cultivars (10). Thresholds are not used in processing sweet corn, where cosmetic damage to the husk is unimportant (7).

Chemical Controls:

In most years, on most cultivars, disease occurrence is insufficient to warrant treatment, and no fungicide is used. Rust can cause cosmetic damage and reduce yields on certain fresh market and processing varieties some years. When necessary, 2 applications of propiconazole (4 fl oz 3.6 EC/A Tilt) may be applied to less than 10% of late season fresh market and processing sweet corn acreage (24). Mancozeb (1.5 lb 80WP/A) is occasionally used instead, particularly on late season corn when the disease appears early in corn development. In this case a 7 day spray schedule is used (7).

Nematodes

Nematodes

Several genera of nematodes are pathogenic to corn in the Northeast (10), and some of these are found in Maryland soil samples; however, the population levels present are usually insufficient to cause economic damage to sweet corn. Nematicide use has not been recommended for sweet corn in Maryland (33).

Weeds

Weed Management in Sweet Corn

Weed management is an important issue in sweet corn, since weeds account for about a third of all crop losses. Weeds result in economic losses in sweet corn in several ways, including: 1) reduction of yield due to competition for water, nutrients, light and possibly CO₂; 2) increasing production costs or reducing yields by interfering with harvest; 3) reduction of effectiveness of insect and disease control measures due to weed interference; and 4) reduction in yield due to crop injury resulting from weed control measures. An integrated approach, including a combination of cultural and mechanical methods, crop rotation, and herbicides, provides the most economical and effective weed management in sweet corn. This integrated approach focuses on proper herbicide selection and optimal timing of application in combination with cultural practices to increase the competitive ability of the crop relative to weeds (5, 10).

Major Weeds

Weeds can be classified taxonomically as grasses, broadleaf weeds, or sedges, and also can be categorized based on their life cycle. Annual weeds germinate in the spring, summer, or fall, depending on species, but all produce seed and complete their life cycle within a year. Biennials take two years to complete their life cycle, while perennials live more than two years. Most perennials can reproduce vegetatively by rhizomes, stolons, bulbs, tubers, and tap roots, in addition to producing seeds. Both the classification and life cycle (including mode of reproduction) of a weed affect how it is best controlled by chemical or other means. The majority of weed control efforts in sweet corn focus on annuals, particularly those that germinate in the summer. Perennial weeds can be a problem in sweet corn, particularly creeping perennials, which reproduce by vegetative means. These are hard to control and can be spread by tillage. There are no significant biennial weeds of sweet corn (10).

Important annual grassy and broadleaf weeds of sweet corn are listed in tables 1 and 2, respectively, and important perennial weeds are listed in table 3. Weeds are listed in each table in order of importance in the absence of herbicides, which may not correlate with the percentage of acres infested. Rankings change, depending on herbicide effectiveness. A weed's importance is related to its aggressive, competitive growth habit along with high weed populations occurring on crop land. The average % yield loss attributed to each weed under optimal conditions (column 3) reflects many factors, including proper choice of herbicide, accurate application, good weather conditions, and cultural practices such as cultivation and rotary hoeing. The average % yield losses listed under unfavorable conditions (column 4) are typical of those that occur when insufficient or excessive rainfall follows herbicide application with normal cultural practices including cultivation. Excessive rainfall results in leaching of herbicide while insufficient rainfall favors weed development over the crop; both situations result in poor weed control (14, 30). Of course, poor control decisions or other types of errors can lead to greater losses than those depicted in the tables (14).

Table 1: Annual grass weeds in sweet corn.

species	% acres infested	average % yield loss	
		optimal conditions	unfavorable conditions
fall panicum	80-90	5	20
large crabgrass	95	1	10
giant foxtail	60	2	15
yellow foxtail	60	1	8
barnyard grass	30	1	10
green foxtail	25	1	8
Texas panicum	5	1	15

Table 2: Annual broadleaf weeds in sweet corn.

species	% acres infested	average % yield loss	
		optimal conditions	unfavorable conditions
common lambsquarters	95	3	9
redroot pigweed	75	2	7
morningglory	100	2	12
common ragweed	90	3	13
Pennsylvania smartweed	30	1	5
cocklebur	20	1	21
velvetleaf	10 _a	1	26
common purslane	85 _b	0	5
galinsoga	25 _b	1	6

a. Significantly higher west of the Chesapeake Bay

b. Significantly lower west of the Chesapeake Bay

Table 3: Perennial weeds in sweet corn.

species	% acres infested	average % yield loss	
		optimal conditions	unfavorable conditions
yellow nutsedge	80	1	10
johnsongrass	25	1	30
horsenettle	30	2	15
bermudagrass	20	1	5
Canada thistle	15 _a	5	10
field bindweed	25	3	10
quackgrass	5	1	20

a. Significantly higher west of the Chesapeake Bay

Integrated Approach to Weed Management

A variety of management practices are combined with herbicide use in an integrated program of weed management in sweet corn in Maryland. These practices include planting at high densities, fertility practices which favor the crop over the weed, crop rotation, and mechanical control of weeds (10). Sweet corn is generally planted in rows 36 inches apart (9) but Maryland growers typically use 30 inch spacings, which make corn more competitive with weeds. Broadcasting of fertilizer may benefit weeds more than the crop, since nutrients applied this way may be utilized by weeds before the corn has a chance absorb them. Generally, part of the nitrogen is broadcast and the remainder is sidedressed when corn plants are 8 to 12 inches high, to give corn a competitive advantage. Crop rotation and crop/herbicide rotations are useful for some weed control situations (10). Advanced planning is required for herbicide use where crop rotation is used, since soil persistence of some herbicides may cause injury to certain crops that could follow sweet corn (9).

Several mechanical methods of weed control are used in Maryland, both prior to planting and during the growing season. Prior to planting, moldboard plowing is used on 10% of acres on the Eastern Shore and fewer than 5% of acres west of the Chesapeake Bay. Conservation tillage is used on 80% of acres overall, including no tillage on about 10% of processing acres and about 40% of fresh market acres. During the growing season, cultivation is the primary mechanical control, and is used on 80% of acres on the Eastern Shore and a much lower percentage west of the Chesapeake Bay (14). Many of these practices serve other agronomic purposes, but have an impact on weed control. For certain weed problems, mechanical control methods are useful, but plowing, disking, and other methods of cultivation can spread creeping perennials that propagate by rhizomes. Disking may be used in combination with herbicides for control of these persistent perennials. Annuals are usually effectively killed by disking alone. Cultivation is an important method for control of annual weeds between rows, and is done early in the season, when the crop is most susceptible to weed competition and newly sprouting weeds are most

easily controlled (10). Mulch is not used on sweet corn. Hoeing and hand weeding are not economically feasible means of weed control for commercial growers (5, 14).

No biological control methods are used for weed control in sweet corn in Maryland (14).

All fresh market and processing sweet corn acres in Maryland are scouted prior to planting to determine the weed potential of the field. Herbicide selection is based on the species of weeds present, and the grower's knowledge of previous weed problems in a field. 100% of processed sweet corn acreage is scouted for postemergent weed problems, while only about 30% of fresh market sweet corn is scouted after emergence; the remaining acres are cultivated (14).

Chemical Controls

Herbicides are the most important component of weed management programs in sweet corn. Proper timing of herbicide application is essential for good weed control. The critical period for postemergent weed control in sweet corn is after plant emergence during early growth (10). Herbicides are often applied in combination to get effective control of the particular mixture of weeds in a field. Annual grasses must be controlled prior to crop emergence (9). Herbicides with different modes of action are rotated by most growers to avoid the development of resistant weed populations (14).

The preemergent herbicides for no-till and conventionally tilled corn are listed in the following sections. Paraquat is used only for no-till corn, and 95% of glyphosate usage is in no-till. Glyphosate is also applied at low rates in rare situations where conservation tillage is being used. The same herbicides are generally used for postemergent weed control in no-till and conventionally tilled sweet corn, although 2, 4-D amine is applied more frequently to no-till (14). Herbicides may be applied at slightly higher rates to soils high in organic matter and to no-till fields (30). Differences in usage for fresh market and processing sweet corn are noted under each herbicide.

• No-Till Preemergence Herbicides

West of the Chesapeake Bay, about 40% of fresh market acres are no-till, with some counties much higher (11, 12). On the Eastern Shore, fewer than 20% of fresh market sweet corn acres are no-till. About 10% of processors use no-till planting (7, 14). The no-till cropping system has no effect on the species of weeds present, but there are differences in preemergent herbicide use between no-till and conventional till sweet corn (14). When applying herbicides to no-till sweet corn, it's important to consider sweet corn variety, date of planting, soil fertility practices, insect control, planting equipment, mulch, and weed species in the field. The following herbicides are used for preemergent weed control in no-till sweet corn in Maryland (9):

- •Paraquat - 0.25-0.5 lbs ai/A (1.6 pts/acre of Gramoxone Extra 2.5SC) is used to control existing vegetation. Paraquat gives good control of cocklebur, foxtail species, galinsoga, yellow nutsedge, pigweed species, and common ragweed, and gives good to fair control of large crabgrass, morningglory, common purslane, fall panicum, and common

lambsquarters. It provides poor control of Pennsylvania smartweed (9). In Maryland, paraquat is applied to 14% of fresh market sweet corn acres and less than 1% of processing acres annually, and is only used on no-till sweet corn (14, 29).

- •Metolachlor - 1.5-2 lbs ai/A (1.54-2.05 pts/acre of Dual II 7.8E) provides good residual control of most annual grasses, plus johnsonweed, galinsoga, and pigweed species. It gives good to fair control of yellow nutsedge and common purslane and poor control of common lambsquarters, velvetleaf, and Pennsylvania smartweed. Metolachlor does not control common ragweed, morningglory or cocklebur (9). Metolachlor is the number one herbicide used in processing sweet corn in Maryland, and the number two herbicide used in fresh market sweet corn. Irrespective of tillage, metolachlor is applied to 56% of fresh market acres and 69% of processing acres annually (14, 29).
- •Atrazine - 1-2 lb ai/A (1.2-2.4 lbs/acre of atrazine 80WP) provides good residual control for nearly all annual broadleaf weeds. It gives good to fair control of cocklebur, and fair control of velvetleaf and foxtail species. It provides fair to poor control of large crabgrass and yellow nutsedge, and poor control of the remaining grassy weeds. Atrazine is the number one herbicide used in fresh market sweet corn in Maryland and the number 3 herbicide used in processing sweet corn. Irrespective of tillage, atrazine is applied to 75% of fresh market acres and 48% of processing acres annually (14, 29). (See restrictions on atrazine use below.)
- •Glyphosate - 1-2 lbs ai/A (1-2 qts/acre of Roundup Ultra 4SC) controls existing vegetation in 1 to 3 weeks. It gives good control of most broadleaf and grassy weeds, with the following exceptions: it gives only fair control of yellow nutsedge, morningglory, and common ragweed (9). In Maryland, glyphosate is applied during the growing season to 3% of no-till (or rarely minimum-till) fresh market sweet corn acres annually, and is not used on sweet corn grown for processing (14, 29).

• No-Till Preemergent Herbicide Combinations

Herbicides are generally used in combination to provide the best control for the mixture of weeds present in a field. The following combinations are used in no-till sweet corn (9):

- •Glyphosate + metolachlor + atrazine (rates as above). This is the most frequently used herbicide combination in no-till sweet corn. It is used when existing vegetation includes dense, well-established annual weeds and/or perennial weeds. Glyphosate injury can occur on light soils if application is delayed after seeding (9). (See restrictions on atrazine use below.)
- •Paraquat + metolachlor + atrazine (rates as above). This combination is preferred on sandy soils, or for control of grasses during the early growth stages of the weed (14). It is

used when existing vegetation includes small annual grasses and/or broadleaf weeds (9). (See restrictions on atrazine use below.)

• **Conventional Tillage Preemergence Herbicides**

Preplant Incorporated

Most sweet corn growers in Maryland avoid use of preplant incorporated herbicides, since their application requires extra management and applicators/planters need additional training to adjust equipment properly. Also, an additional tillage event prior to planting increases the likelihood of delayed planting due to rain (14).

- •Butylate - 3-6 lbs ai A (3.75-7.33 pts/acre Sutan+ 6.7EC), incorporated with the soil, gives good control of annual grasses and pigweed species, good to fair control of yellow nutsedge, fair control of morningglory and velvetleaf, and poor to no control of the remaining weed species. It is combined with atrazine or Extrazine (cyanazine + atrazine) to improve broadleaf weed control (9). In Maryland, butylate is applied to less than 1% of fresh market sweet corn acres annually, irrespective of tillage, and it is not used on sweet corn grown for processing (14, 29).

Preplant Incorporated or Preemergence

- •Alachlor - 1.5-3 lbs ai/A (1.5-3 qts/acre MicroTech or 2.3-4.6 lbs/acre of Partner 65DF) is primarily used to control annual grasses and certain broadleaf weeds, including pigweed, common purslane and galinsoga. It suppresses yellow nutsedge when preplant incorporated. It is combined with atrazine or Extrazine to improve control of other broadleaf weeds (9). Irrespective of tillage, alachlor is applied to about 18% of fresh market acres and 26% of processing acres annually (14, 29).
- •Metolachlor - 1-2 lbs ai/A (1.03-2.05 pts/acre Dual II 7.8EC) provides good residual control of most annual grasses, plus johnsonweed, galinsoga, and pigweed species. It gives good to fair control of yellow nutsedge and common purslane, but provides poor control of common lambsquarters, velvetleaf, and Pennsylvania smartweed. Metolachlor does not control common ragweed, morningglory or cocklebur. It is used as preplant incorporated to improve yellow nutsedge control. Metolachlor is combined with atrazine or Extrazine to improve control of most broadleaf weeds (9). Metolachlor is the number one herbicide used in processing sweet corn in Maryland, and the number 2 herbicide used in fresh market sweet corn. Irrespective of tillage, metolachlor is applied to 69% of processing acres and 56% of fresh market acres annually (14, 29).
- •Atrazine - 1-1.5 lbs ai/A (1-1.5 qts/acre of atrazine 4FL) provides good residual control for nearly all annual broadleaf weeds. It also gives good to fair control of cocklebur, and

fair control of velvet leaf and foxtail species. It gives fair to poor control of large crabgrass and yellow nutsedge and poor control of the remaining grassy weeds. It is combined with butylate, alachlor, or metolachlor to improve control of annual grasses (9). Atrazine is the number one herbicide used in fresh market sweet corn in Maryland, and the number 3 herbicide used in processing sweet corn. Irrespective of tillage, atrazine is applied to 75% of fresh market acres and 48% of processing acres annually (14, 29). (See restrictions on atrazine use below.)

- •Cyanazine - 0.5-0.75 lbs ai/A (0.55 to 0.83 lbs/A of Bladex 90DF) gives good control of many broadleaf weeds, including common purslane, common lambsquarters, and galinsoga. It gives fair control of common ragweed, cocklebur, and morningglory, but provides poor control of velvetleaf, pigweed, and yellow nutsedge (9). It is typically applied as a tank mix with atrazine to reduce the risk of atrazine carryover by using ultra-low atrazine rates (14). It is combined with alachlor or metolachlor to control annual grasses and pigweed species (9). Growers may choose cyanazine in place of atrazine to eliminate the potential for herbicide carryover, which restricts the crops that can be planted following corn harvest (14). The lower rate is used on loamy sands and sandy loams, or on soils with less than 2% organic matter. The higher rate is used on silt loam and clay loam soils or on soils with more than 2% organic matter. Cyanazine is not applied to soils classified as sands or loamy sands with less than 1% organic matter, if corn has emerged, or if soils are cold or wet, as crop injury may result. Sweet corn varieties may differ in tolerance to cyanazine, so it is used with caution on new varieties (9). Cyanazine is the number 3 herbicide used in fresh market sweet corn in Maryland, and the number 2 herbicide used in processing sweet corn. Irrespective of tillage, cyanazine is applied to 23% of fresh market acres and 53% of processing acres annually (14, 29).
- •Simazine has a longer soil residual than atrazine, and is generally avoided by vegetable growers for this reason. Simazine is not used on processing sweet corn, where double cropping is common, because of the risk of injury to vegetable crops following sweet corn (14). 1-2% of fresh market sweet corn acres in Maryland are treated with simazine annually, irrespective of tillage, primarily for better fall panicum control than can be achieved with other products (14, 29). The small amount of simazine applied by Maryland sweet corn growers is generally applied in a tank mix with atrazine at a rate of 1.0 lbs ai/A atrazine + 1.0 lbs ai/A simazine. Many fresh market growers will not plant another crop until next year, and simazine does not injure the following rotational crop if the total triazine rate is not greater than 2.0 lbs ai/A (14).
- •Cyanazine + atrazine - 0.5 lbs ai/A + 0.125 lbs ai/A (0.7 lbs/acre of Extrazine 90DF). Extrazine is a combination of cyanazine (Bladex) plus atrazine which is labeled for use in sweet corn and reduces the risk of atrazine carryover by greatly reducing the rate of atrazine applied (9). This combination provides good broadleaf weed control and the atrazine prolongs soil residual control over that obtained with cyanazine alone (14). It is

combined with butylate, alachlor, or metolachlor to improve control of annual grasses. Extrazine is not applied to sweet corn after the crop has emerged, as injury may result. Restrictions to atrazine products apply (see below) (9).

- •Cyanazine + Metolachlor - - 0.5 lbs ai/A + 1 lbs ai/A. This combination is used on about 50 acres (0.4%) of fresh market sweet corn planted into plastic. The material is applied during bed preparation (11).

• **Postemergence Herbicides - No-till and Conventional Tillage**

Early Emergence

- •Atrazine - 1-2 lbs ai/A (1-2 lbs/acre of atrazine 80WP) is applied when weeds and corn are up to 2 inches tall. It is primarily used to control broadleaf weeds (see above). Annual grass control will be minimal with atrazine. Atrazine is the number one herbicide used in fresh market sweet corn in Maryland, and the number 3 herbicide used in processing sweet corn. Atrazine is applied to 75% of fresh market acres and less than 48% of processing acres (14, 29).

Restrictions on atrazine use require that the lowest recommended rate be used when it is combined with an annual grass herbicide, and to reduce the risk of atrazine residues, which may injure certain crops following sweet corn in the field (9). Experience has shown atrazine at low rates has a greatly reduced potential to injure sensitive rotational crops. It has been found that atrazine rates of less than 2.0 lbs ai/A do not affect any rotational crops in the next cropping season (14). Restrictions on use prevent double-cropping during a season when atrazine or any atrazine-containing products are used (9). However, in practice it has been found that atrazine rates of less than 1.0 lbs ai/A do not affect double crops, such as soybeans, planted 45 days after postemergent atrazine use in sweet corn (14). Grass cover crops can be established after corn harvest, provided the recommended rate of atrazine was not exceeded. Moldboard plowing before planting a crop sensitive to atrazine is recommended to minimize the risk of injury from atrazine residue (9).

Postemergence

- •Bentazon - 0.75-1 lbs ai/A (1.5-2 pts/acre of Basagran 4SC) is applied when weeds are young. It gives good control of common ragweed, Pennsylvania smartweed, cocklebur and velvetleaf, and fair control of common lambsquarters, galinsoga, and yellow nutsedge. Grasses are not controlled with this product (9). About 30% of growers using bentazon cultivate fields within 10 to 14 days to increase control (14). Bentazon is applied to about 4% of fresh market sweet corn acres annually, and is generally not used on sweet corn grown for processing, except in emergency situations (14, 29).

- •2,4-D amine - 0.25-0.5 lbs ai/A (0.5-1 pts/acre of 2,4-D amine 4EC) is applied after corn and weeds emerge. It gives good control of most broadleaf weeds, but only fair control of Pennsylvania smartweed. Yellow nutsedge and galinsoga control is poor, and grasses are not controlled with this product. Drop nozzles are used when corn is over 8 inches tall to avoid spraying onto the foliage or into the whorl of the corn. During warm, wet weather, application of this product may increase the possibility of crop injury. The lower recommended rate is used when these conditions prevail. Growers delay cultivation for 8 to 10 days after treatment to avoid damaging corn due to temporary brittleness sometimes caused by 2,4-D. Sweet corn varieties differ in 2,4-D tolerance. 2,4-D amine is used with caution on new varieties and is not applied from tasseling to dough stage (9). 2,4-D ester formulations, although labeled, are more subject to volatilization and movement to sensitive crops and, therefore, are not used by Maryland sweet corn growers (9, 14). 2,4-D amine is used most frequently in no-till sweet corn. It is applied to about 5% of fresh market sweet corn overall annually, and is not used on sweet corn grown for processing in Maryland (14, 29).

• Postharvest Herbicides

Postharvest application of herbicides is an important weed management technique. It is used to control weeds that are difficult to manage during the growing season due either to selectivity of the herbicide or the timing of application. It is also used in double crop situations, to kill the weeds remaining in the field prior to planting of the rotational crop (30).

- •Glyphosate is the most common herbicide applied after harvest in Maryland (14). It is typically applied at a rate of 1.5-2 qts/acre to healthy weed foliage in late summer or early fall (9).
- •Paraquat - 0.5-0.6 lbs ai/A (1.5-2 pts/A of Gramoxone Extra 2.5SC). A Special Local-Needs (section 24(c)) label has been approved for the use of Gramoxone Extra 2.5SC for postharvest desiccation of the crop in Maryland and Virginia. It is applied as a broadcast spray after the last harvest (9). Used as an alternative to tillage, postharvest paraquat application can help reduce soil erosion. Paraquat is seldom applied postharvest by Maryland growers (14).

Chemical Control Issues for Herbicides

The triazine herbicides (atrazine, cyanazine, and simazine) are the most effective herbicides available for corn, and form the foundation for efficient weed control programs in sweet corn in Maryland. Atrazine is currently used on about 75% of fresh market and 48% of processing sweet corn acres. Cyanazine is used on about 23% of fresh market and 53% of processed sweet corn acres. Simazine is not used in processing sweet corn and is used on about 2% of fresh market acres. These products are generally applied at the lowest labeled rates or below labeled rates, to protect the environment and avoid rotational

vegetable crop injury, because most growers of sweet corn grow other vegetables. The potential loss of the triazine herbicides poses economic and management concerns because alternative herbicides are more expensive and some alternatives, such as 2, 4-D, are not compatible with intensive vegetable production in neighboring fields and farms (14).

The genetic diversity of sweet corn varieties results in variable tolerance to the newly developed herbicides used on field corn. Potential alternatives, such as 2, 4-D, are only used on a small percentage of fresh market acres, and not at all in processing corn, due to this variable tolerance issue. Dicamba, used extensively for broadleaf weed control in field corn, cannot be used in sweet corn because it disrupts fertilization and results in a failure of kernel development. Newly registered for certain processing sweet corn varieties in 1999, nicosulfuron postemergence has the potential for a reduced soil residual alternative to cyanazine, however, the current label prohibits double crop rotations for vegetables. University of Maryland researchers will be working with the manufacturer during the 1999 growing season to determine if nicosulfuron can safely be used on sweet corn with same-season rotational crops such as snap beans, lima beans, cucumbers and spinach. Such double crop rotations are common to the unique same-season multiple cropping situations on the Eastern Shore of Maryland, and a special local need registration may be requested if rotational crop injury is not a problem (14).

Triazine resistance has been less frequent and less severe on the Eastern Shore than in areas of Maryland west of the Chesapeake Bay, although some resistance has developed on the Eastern Shore among localized pigweed, cocklebur and lambsquarters populations (7, 14). A possible explanation for this regional difference is that crop rotations are generally more intense on the Eastern Shore (14).

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