

Crop Profile for Sweet Corn in the North Central United States

Prepared: November, 2003

General Production Information

The twelve states of the North Central Region produce about one half of the processed sweet corn in the United States. Most of this production resides within an area from western Indiana through northern Illinois, and southern Wisconsin and Minnesota. Fresh market sweet corn is also grown throughout the Midwestern region for sale at retail grocery stores and roadside stands. The total value of sweet corn grown within the United States exceeds \$800 million. Sweet corn is an important table vegetable with Americans eating about 30 pounds of corn per person per year (canned, fresh and frozen).

The profit margins for most sweet corn tends to remain quite low, being typically tied to grain corn prices. With marginal returns, producers are looking for opportunities to reduce the costs and risks and maintain their economic viability. This crop profile offers a glimpse into the opportunities and challenges producers face in trying to maintain a profitable and secure industry. The original draft of this crop profile was developed from a Pest Management Strategic Plan (PMSP). The PMSP workshop was held in Madison, Wisconsin on the 17th and 18th of December, 2002.

Background:

Over 700,000 acres of sweet corn (*Zea mays*) are grown in the United States each year. This acreage consists of sweet corn for both fresh market (242,000 acres) and processing (467,000 acres). The twelve North Central Region states are responsible for approximately 50% of the nation's processed sweet corn. Within this region the majority of the commercial production of processed sweet corn is located near the processing plants which dot the region from southern Minnesota and Wisconsin to northern Illinois and Ohio. While some of the fresh market acreage is grown under contract, a considerable amount is produced for roadside stands and local farmers' markets. The fresh market production for the region is distributed throughout the North Central Region with higher production occurring near large cities.¹

Markets:

Sweet corn consumption has increased considerably over the past 30 years. In 1970, each American consumed approximately 5.8 pounds of corn/year while this amount has increased to about 30 pounds/year today. There is a large international market as well, as indicated by sweet corn imports and exports. The total export value of canned sweet corn in 2001 was \$220 million. Canned and frozen imported sweet corn, primarily from Canada, totaled \$16 million in 1999.¹

Table 1. Area, production, and value per hundredweight and per ton, by State, 2002

Processed sweet corn	2002 Acres	2002 Tons	2002 Dollars per ton
IL	13,800	80,040	93.00
MN	136,900	884,630	64.61
WI	84,200	596,050	56.24
US	419,900	3,142,840	66.94
Fresh market	2002 Acres*	2002('000) boxes**	2002 price per box
IL	5,600	1,302	7.23
IN	5,100	784	9.88
MI	10,000	1,860	9.03
OH	14,400	2,914	9.12
WI	7,500	1,100	9.03
US	248,800	61,465	8.64

* An inability to track the numerous growers who produce sweet corn for roadside markets and local outlets may result in some underestimation of total production of fresh market. A box is considered to be 50 ears and requiring about 43 pounds of bulk mechanically harvested corn.

** Estimated. The above tables available from USDA-NASS Agricultural Statistics 2002 with conversion of hundred-weight figures to the market convention of boxes harvested. Box prices may appear high but are influenced by roadside market prices.

<http://jan.mannlib.cornell.edu/reports/nassr/fruit/pvg-bban/vgan0103.txt>

Cultural Practices

Planting, Tillage, and Fertilization:

Sweet corn is similar to field corn and thrives under similar conditions. The deep fertile soils, moderate rainfall and temperate weather of the Midwest are ideal for high yields and quality. Relative to field corn, sweet corn is a high value crop and as much as 20 percent of all sweet corn may be irrigated. Fields are generally fertilized at levels below that of field corn and may be side-dressed with an application of nitrogen later in the season. Fields are generally tilled to reduce weed competition.

Sweet corn must be harvested within a very short time of optimal maturity so planting dates are staggered over a period of weeks to permit a longer harvest period. Another tactic used by producers to

lengthen the harvest period is to plant hybrids with different maturity dates. The typical early planting date for sweet corn is one to two weeks before the frost free date in the region but may be somewhat later for the Sh₂ genotypes. The planting period may extend into the first week of July. Harvest timing for the processor will be scheduled to maximize plant utilization. For the fresh harvest timing is scheduled to coincide with desirable market windows. Harvest timing will depend on genotype, however. The Sh₂ types dominate the fresh market trade and are now being used more extensively by processors. Early planting tends to be less critical for processors, as there is no market advantage for early processed corn, but it does help distribute loads at processing plants. For fresh market producers the last planting can extend to the first week in July. Producers who grow sweet corn on contract are always assigned planting dates by the processor for the corn hybrids they grow.

Average field size for sweet corn produced under contract is 40-80 acres. The range of acreage contracted per grower is 80-240 acres. Most fresh market sweet corn fields range in size from 1- 40 acres with a few exceeding 100 acres.

General Pest Control Comments:

Most herbicides are applied at pre-emergence because sweet corn is not very competitive with weeds and there are few post-emergence weed control options. Nicosulfuron, atrazine, bentazon, and carfentrazone may be used for postemergence control of wild proso millet and other weeds. Nicosulfuron is restricted to a few tolerant lines and is used for processing sweet corn only. Insect and disease control are very important for sweet corn produced for the fresh market. Consumer expectations for blemish free produce results in regular insecticide and fungicide use. An analysis of NASS survey data for the U.S. indicates that fungicide and insecticide use on fresh market sweet corn was higher than for processed corn (i.e. over 4 pounds a.i. per acre vs. 0.15 - 0.66 pounds a.i. per acre)³. However, this difference may result from the greater portion of the fresh market sweet corn being produced in the southern U.S., an area where pest pressure is considerably greater than in the upper Midwest.

The amount and frequency of pesticide use is determined by which pests are present and by prevailing weather conditions. Survey statistics indicate that insecticide and fungicide use can vary by a factor of two from year to year. Sweet corn producers are sensitive to the issue of pesticide reduction, and use non-pesticide methods of control whenever it is perceived that they are economically viable. Crop scouting is practiced on the majority of acres (~85%). Processing plant personnel and field reps will scout close to 100 percent of acreage under their contracts. Crop consultants and the growers play a major role in scouting fresh market sweet corn. Processors rely on pheromone traps for detection of corn ear worm in over 70% of contract fields. Blacklight traps are also used for monitoring European corn borers. Field sanitation and water management are other options utilized but with less frequency.³ Adjusting planting dates is used by sweet corn producers to stagger harvest for processing plants and for continuity of fresh market sales.

GMO Comments:

GMO sweet corn has met great resistance world-wide. The perception that many consumers have is that GMO's are harmful and hence, sweet corn hybrids with GMO traits have not yet been accepted by consumers. If consumers were to accept GMO sweet corn, the Bt type hybrids could reduce or eliminate spraying pesticides for control of corn borers and possibly corn earworms and fall armyworms. It is also possible that Roundup Ready or Liberty Link sweet corn could reduce the risks of crop losses many growers now face should atrazine be cancelled. Education is needed to demonstrate that GMO plants and seeds can be safe to humans and the environment. It is also important to communicate that GMO plants may increase biodiversity while reducing unwanted chemicals in our water, soil, air, and food.

Synthetic Chemical Free Production:

The production area of certified organic sweet corn is a small fraction (<5%) of that which is conventionally produced. Nearly 95% of the organically grown sweet corn is scouted for pests and nearly all that is done by the grower. The use of beneficial organisms (46%), habitat provision (67%), resistant hybrids (80%), and water management (33%) and adjusting the planting date (56%) were quoted on surveys as practices regularly implemented by organic growers. ³

Harvest Practices and Yields:

The average harvest date for sweet corn is 70-85 days after planting. When corn is planted very early in the season it is not uncommon for 80 day corn to require 100 or more days to actually mature. Some fresh market producers employ manual labor for hand picking ears from the plant while larger commercial producers often use mechanical equipment. Due to the influence from chain store buyers and the cost of harvesting equipment, the trend in recent years has been back to hand harvesting. This trend may continue as long as labor is available. Sweet corn yields range from 4 to 9 tons/acre. Small plots harvested by hand may typically yield 12 to 20,000 ears per acre.

Because sweet corn will rapidly lose freshness and begin to degrade after harvest, refrigeration or icing fresh market sweet corn during transport can be employed. Lowering the temperature helps to retain the high sugar content within the kernels before reaching market. Overly mature crops may be harvested as cattle fodder or used for corn silage.

Pest Resistance Issues

Herbicides: Weed resistance to herbicides is now recognized as a major threat to sweet corn production. Pre-emergence applications of atrazine followed by postemergence applications of atrazine were relatively common and led to resistance. Weed species resistant to the triazine herbicides now include common lambsquarters, giant foxtail, kochia, smooth and redroot pigweed, and velvetleaf.

Insecticides: Insect resistance development is of concern in both fresh market and processed sweet corn. Fields often receive multiple insecticide treatments as a means of reducing the insect contamination of

fresh or processed corn that is deemed unsatisfactory by consumers. European corn borer, *Ostrinia nubilalis* Hübner, and corn earworms *Helicoverpa zea* Boddie, are the pests which are of principal concern in the North Central Region. Late-planted sweet corn is more susceptible than early-planted fields and typically requires more insecticide treatments. The European corn borer and the corn earworm have other hosts including field corn, and as a result have little potential to develop resistance from current sweet corn treatments.

Fungicides: Although resistant hybrids tend to be the most common control mechanism, resistance to fungicides is of greatest concern in fresh market fields which may receive repeated fungicide treatments. A new race of common rust has recently appeared that is virulent to Rp1D hybrids. Host resistance to common rust in sweet corn was based entirely on Rp1D until 2001.

Worker Exposure Issues

Applicators/loaders: Approximately 90% of all herbicides applied to sweet corn grown under contract are applied with equipment utilizing air filtration systems. It is estimated that an applicator operating a ground rig will take approximately 1 minute for each acre/pesticide application. This includes mixing, loading, and application, but not transit time to get to and from the fields. Each acre of contract sweet corn receives approximately two herbicide applications per season, one pre- and one post-emergence.

Only 1 to 3 percent of contract sweet corn fields are treated with a soil applied insecticide at planting. Later in the season, however, nearly all fields grown for contract receive 2 to 5 post-plant insecticide treatments for European corn borers and corn earworms (average of 3). More than 90% of the foliar applied insecticides are aerially applied. Insecticides used on small plots produced for roadside stands and farmer's markets are applied with a host of less sophisticated equipment. It is unknown whether locally-grown, small sweet corn acreage not produced under contract has less frequent insecticide applications than acreage grown for contract.

Planting takes approximately one day for each 100 acres of corn grown. During planting, growers handle bags of seed that have a fungicide seed treatment, refilling planting boxes an average of five times with approximately 10 minutes per refill. Leather gloves worn during refill operations are typically the only safety equipment used.

Other workers exposed to pesticides include the applicator, handlers/loaders, planter operators, chemical delivery people, and the laundry service workers who wash such clothes. Contact with pesticides may occur as a result of equipment maintenance and calibration, normal pesticide application, equipment clean-up, or spills. For estimations of worker exposure for processed and fresh market sweet corn see Appendices F and G.

Crop scouts: Some crop scouting takes place during the six week period immediately after planting. During this period physical contact between the crop scout and pesticide residues on the soil or

emerging crop is minimal. After this initial period some insect and disease scouting in standing corn is necessary. Although many field scouts wear vinyl rain suits while in the fields due to the heavy dew that can occur, it is possible that bare arms and skin may be exposed to latent pesticide residue. Furthermore, to determine actual levels of pest infestation some handling of plant material may be required by the scout in the field. Good communication between field scouts and the grower minimizes exposure to residues. For estimations of time in field and exposure see Appendices F and G.

Field workers: The availability of effective herbicides has reduced the need for hand hoeing or roguing in fields. More hand hoeing takes place on very small production plots grown for roadside markets. As a practical matter commercial sweet corn is rarely hoed, and then usually for the purpose of thinning a stand due to an errant planter unit or other miscue.

Harvesters: For fields harvested by machines the operator has little or no contact with the plant or the ears. Small plot acreage harvested by hand necessitates contact with plant leaves which may have latent residues of post-emergence applied insecticides or fungicides. Roadside growers may pick the ears and toss them onto a wagon or into a tote sack. Fresh market grower shippers will, if they pick by hand, most often also pack the corn in the field using a harvest aid or "mule train". This operation may involve the grower, his family, and/or other laborers. For sweet corn harvested by hand, gloves made of cloth or light leather are generally used. See Appendices F and G for estimated exposure of harvesters.

General Pesticide Application Information

Herbicides: It is estimated that less than 10% of all herbicides are applied to sweet corn in the granular formulation. Ninety-nine percent of all herbicides are applied by ground application equipment. New, water-dispersable herbicides available as a dry formulation have reduced dust inhalation risk. Dry formulation packaging has also reduced container disposal issues. Exposure by farmers or custom applicators during mixing and loading has not been well researched to date, but we can speculate that the increased usage of dry-formulated pesticides has great potential for reducing handler exposure.

Insecticides: Soil insecticides are applied by the grower during planting while foliar applied insecticides are applied once the crop has emerged from the soil. Small acreage growers who apply insecticides may be at higher risk of exposure than large acreage growers who contract with aerial applicators. Nearly 90% of all foliar insecticides are applied by aerial application to large production fields and result in little or no exposure to the applicator. Smaller fields would typically use ground application equipment and may result in a higher incidence of exposure. Insecticide handling time is approximately 10 minutes for every 100 acres of sweet corn for aerial application.

Fungicides: Foliar fungicides on sweet corn has been estimated at 10 to 50 percent of the acreage annually.

Post harvest handling: Post harvest exposure to latent pesticide residues may be an issue for fresh

market sweet corn. In fresh market production, corn is graded, sorted, and then packed by hand prior to cooling. Processed corn is inspected by hand, after it has been husked, while it passes on a conveyor belt. The degree to which handlers, sorters, and graders use protective equipment is unknown.

Environmental Exposure Issues

General: Approximately 10-20% of sweet corn is produced on irrigated land. Although no figures are available, much of the irrigated land in the Midwest is on sandy soils with shallow groundwater. Therefore, where sweet corn is produced on irrigated land there is an increased risk of groundwater contamination by pesticides. Although many small acreage producers are close to large cities, the fields of most contract growers will be several miles from large metropolitan centers.

Herbicides: Cyanazine, which has been associated with ground and surface water contamination, has been removed from the market and will no longer be available for sweet corn producers. Atrazine, another herbicide that has been found in ground and surface water, is widely used by most sweet corn producers, but is not available in some regions (Parts of Wisconsin) due to local restrictions. The acetamide group of herbicides (alachlor, metolachlor, dimethenamid) are used on up to 90% of the sweet corn in the region for preemergence grass control. They are known to contaminate water resources and can be a problem in areas with very shallow groundwater or high levels of soil erosion. Post emergence herbicide use on sweet corn poses less environmental risk than soil applied products.

Insecticides: With the low use (2-3%) of soil insecticides there is little risk to avian or aquatic life. The widespread use of the pyrethroid class of insecticides may reduce populations of beneficial insects in localized areas.

Product Registration Issues

Herbicides: Herbicide registration losses (with the exception of cyanazine) have been few over the last several years. However, restrictions have been placed on many herbicides in an effort to reduce contamination of surface and groundwaters. Atrazine, alachlor, and paraquat are all restricted-use pesticides. They may be purchased and applied only by, or under the direction of, certified or licensed applicators. Groundwater advisories have been added to many labels to prevent mixing, loading, and application in areas of high risk for runoff or leaching. Many additional restrictions have been placed on atrazine to limit its application and reduce contamination of surface and ground water. Additional restrictions likely will be imposed on individual products to limit drift, wildlife exposure, and residues in foods, in addition to groundwater contamination. In southern Wisconsin the loss of atrazine and cyanazine has resulted in a shift to less effective, and more expensive weed control options. Section 18s were issued for glufosinate in 1999, carfentrazone in 2000, and mesotrione in 2002; in Wisconsin for use in the atrazine prohibited areas. Products such as metolachlor, alachlor, and atrazine are also under scrutiny in Minnesota due to ground and surface water issues in areas where sweet corn is grown for processing.

Insecticides: Gaucho seed treatment for control of corn flea beetle and Stewart's wilt is now registered. Cancellation is not imminent for other insecticides as of publication date. Cruiser is to be given a label in 2003.

Fungicides: A section 18 was granted for Imazilil for control of seed and soil-borne fusarium sp. and penicillium sp. during 1999 and 2000. Imidacloprid has also received a section 18 in Idaho and Minnesota for seed to be planted in the Midwest and a few Eastern and NE states.

Critical Alternative Issues:

Specific pesticides or pesticide groups are herein given ratings according to their level of significance to the commodity. Although non-chemical or organic methods of pest management are employed for many production systems, our intent is to focus on commercial agriculture, which generally involves conventional pesticides. There are three rating levels: Level A: product critical, no acceptable alternatives, loss of product would cause regular and drastic changes in production, safety, or commodity price. Level B: product essential, alternatives limited in application, loss of product would cause significant changes in production, safety or commodity price. Level C: product fundamental, alternatives exist, loss of product would cause few changes in production, safety, or commodity price.

Critical Herbicides: (Atrazine, level A,.) The most critical pesticide issue for sweet corn production is the possible loss of atrazine. Currently there are no acceptable alternatives for broadleaf weed control for this herbicide. Although nicosulfuron, (Accent) is registered for use on some select processed sweet corn hybrids, it cannot be used on fresh market corn and it controls very few broadleaf weeds. The use of 2,4-D as a substitute for atrazine is greatly limited due to its propensity for crop injury. Bentazon and carfentrazone control a few broadleaf weed species, but they lack the broad spectrum that is required. Bentazon could be considered Level B herbicide because it has a critical role in use with atrazine in allowing lower use rates and expanding the atrazine spectrum of control at those lower rates. Atrazine is very commonly used on sweet corn and its loss would result in significant changes in production, most notably a reduction in sweet corn acreage planted and a reduction in per acre yields, and hence a significant increase in cost of the sweet corn produced. The loss of atrazine would also require more in-field hoeing of weeds, exposing field workers to more insecticides.

The loss of the acetamides as a group could also be considered level A significance. Used primarily for grass control, there are no alternatives that provide equivalent efficacy. Butylate and EPTC as alternatives may provide some control but at the risk of increased crop injury. Neither of these products have formulations that are generally available, however. Pendimethalin generally provides less efficacy than the acetamides but its use significantly increases the risk of injury. The loss of the acetamides would necessitate additional cultivations and would result in yield reductions of up to 30 percent in some years.

(All other individual herbicides, level C)

Critical Insecticides: (Pyrethroids as a group, level A) In an effort to reduce OP and carbamate residues on sweet corn, pyrethroids are now the product of choice for foliar-applied control of corn borer and corn earworm. If pyrethroids were no longer available sweet corn quality would decline significantly and prices would go up drastically. In addition, the amount of insecticide active ingredient would go up drastically. Gaucho seed treatment to control corn flea beetle and Stewart's wilt is critical in some areas (level A). (All other individual insecticides, level C)

Critical Fungicides: (Fludioxonil, "Maxim", or Mefenoxam, "Apron", level B, loss of both classed as Level A.) Both of these products are widely used as seed treatments for sweet corn. Unlike field corn, sweet corn is particularly vulnerable during germination. Super sweet hybrids have exceptionally low vigor during emergence. The protection afforded by these products can be critical in cool wet soils where *Pythium* and *Fusarium* species are prevalent. These products are also necessary for control of seed-borne and soil-borne *Penicillium* species.

Captan can be classified as an alternative to fludioxonil and mefenoxam but is less efficacious.

("Quadris", azoxystrobin, Level B) Although foliar treatment for rust has been minimal (on processed sweet corn) over the last decade, a virulent race has recently developed which affects Rp1D hybrids and may require more foliar fungicide over the next few years. Plant breeders will need from 3 to 6 years to breed greater resistance into current hybrids. Quadris is expected to provide the systemic protection necessary to protect the crop in the interim and use may approach 35 to 40 percent of the entire sweet corn crop. It is easy to imagine some years where the rust could devastate the crop without Quadris; suggesting a possible Level A ranking. For fresh market sweet corn zinc ion maneb is also considered important, especially for resistance management. (All other fungicides, level C)

Co-occurrence of Pesticides

Herbicides: Atrazine will be used primarily with a grass control herbicide such as metolachlor, alachlor, or dimethenamid. These latter products are seldom used in combination with other acetamides and are not often used sequentially on the same field. (< 5% of crop) Atrazine is often used with bentazon for broadleaf control and is an ingredient in the package mix Laddok.

Insecticides: The majority of insecticide applications are foliar-applied pyrethroid treatments. Very seldom is more than one product applied during a single treatment. However, it is common, especially for larger growers, that more than one pyrethroid be applied in sequential applications. (> 90% of crop) Growers with smaller acreage may purchase a single product for repeated use.

Fungicides: The application of more than one foliar fungicide during a season, either in a combination or sequential application, is very rare. (< 1% of crop) The use of a combination of products to expand

the efficacy of seed treatments is common. (>50% of seed treated)

Weeds

Weeds are present in every field every year. The severity of the weed population is determined by local management practices such as the previous crop, fall and spring tillage, crop rotation, and herbicide use. The prevalence of specific weeds throughout the region is dependent upon soil type, rainfall and moisture, temperatures, and day-length for the region. Although losses from weeds in field corn average from 3 to 7 percent annually, losses attributed to weeds in sweet corn total losses can be 15 percent or more.

Sweet corn yield losses due to weeds are predominantly caused by competition for soil moisture. In years when rainfall is limited, not only does the presence of weeds reduce the amount of moisture available for the crop, but a lack of rainfall early in the season also reduces the effectiveness of herbicides, resulting in an abundance of weeds. Stunting crop growth at any time during the season results in an overall reduction in each plant's potential to produce and fill a large ear, while moisture stress on the crop during the early ear formation can reduce the number of kernels which develop.

Although less common, weeds also reduce photosynthesis by shading the corn plant. Because corn grows quickly and an upright growth habit, in order for significant shading to occur weeds must grow faster than the corn or must start growing before the corn emerges. Typically, dense populations of weeds are necessary for shading to have much effect on the overall yield of the crop. The reduction in yield from shading occurs as a result of the formation of smaller ears of corn on each plant.

In addition to the yield and quality factors mentioned above, weeds also provide a habitat for insects, and when found in sufficiently dense populations, can change the microclimate in the field to favor plant diseases. Some weeds may also be a problem at harvest as they clog machinery or reduce its efficiency in separating the ears from the plant.

As many as 30 different plant species are commonly found as weeds in agronomic crops in the North Central Region. Although it is beyond the scope of this publication to detail how each herbicide interacts with each weed, in addition to identifying plants as either grasses or broadleaves, there are some plant groupings that are useful to understanding the general tendency of groups of plants to tolerate or be susceptible to herbicides. These include plant life cycle, seed size and germination characteristics, and a tendency to develop resistance to herbicides.

Most common weeds can be divided into three categories: grasses, broadleaves, and sedges. Plants of a particular category may have a tolerance to herbicides through shared attributes such as physical characteristics, cell structure, or biochemical processes, which may prevent a herbicide from entering the

plant, inhibit its movement within the plant, or deactivate the herbicide before it can attack plant processes. For example, the growing point of grasses is below the soil surface during early growth and is protected from the non-translocated post-emergence herbicides that are effective on emerged broadleaf weeds. Other shared physical characteristics, such as a protective leaf sheath which encloses newly emerging grass seedlings, or the ability of a broadleaf plant to generate new shoots from leaf axils, may also lend tolerance or susceptibility to herbicides. While there are many common characteristics that are shared by each category, there are also individual plant characteristics that separate individual species and result in differential susceptibility among plants within the category. The key to weed control is to select herbicides which have characteristics that fit the general category of weeds, but note specific weeds in the field that might respond differently from others to the candidate herbicides.

Plant life cycle also plays a part in weed tolerance to herbicides. Perennial weeds, such as Canada thistle, common milkweed, and bindweed, have deep and extensive root systems that allow them to regenerate new emerging shoots after existing ones have been killed. Most perennials, unlike annuals, require herbicides which are translocated to the roots for effective control. The root systems are so extensive that only multiple treatments over several seasons are sufficient to kill plants. Perennial plants also tend to invest more reproductive energy in their root systems than in seed production. As a result, few plants arise from seed and those which do are seldom a significant concern. The most effective herbicides for perennial weeds are those which translocate within the plant and will be foliar applied at a time when the plant is translocating photosynthates from the leaves to the roots. Although contact (non-translocated) and soil-applied herbicides may have some deleterious effect on the growth of perennial weeds they seldom provide effective long term control.

Weed seed size and germination characteristics also dictate which herbicides may be effective. Plants arising from larger seed, such as from cocklebur, jimsonweed, and velvetleaf, tend to germinate at soil depths and at times during the season (April, May or early June), where moisture is plentiful. Many of these weeds are difficult to control with pre-emergence herbicides only and may require post-emergence herbicides for adequate control.

On the other hand, small seed, such as from most grasses, pigweeds, and lambsquarters, tends to germinate at times throughout the season when light rains have moistened the soil surface or where crop residue keeps the surface moist (no-till). Of those weeds which do germinate late in the season, some are shade tolerant and grow well under the crop canopy to become significant problems (black nightshade, prickly sida), while others wither and die or never grow beyond a few inches in height. Weeds that tend to be problems late in the season must be controlled by herbicides which are persistent in the soil or controlled by late-season "rescue" post-emergence applications.

Finally, one other plant characteristic must be considered before a herbicide is selected; the presence of, or tendency to develop, herbicide resistance. There are 20 common weed species in the Midwest that now have resistance to herbicides. Though a particular species may not be resistant to herbicides some have a predisposition to develop resistance due to a genetic or physical characteristics. Some of these characteristics include cross-pollination, prolific seed production, and a genetic capacity to adapt. Plants which exhibit more than one of these characteristics are the most commonly found resistant plants

(kochia, waterhemp, pigweeds). In nearly every field in the Midwest herbicide resistance is now of concern. Herbicide selection must focus on rotating herbicides or combining herbicides with different modes of action. <http://www.weedscience.org/in.asp>

Annual Grasses

Biology and Life Cycle:

Grass weeds germinate at soil depths from 1/8th of an inch to 2 or 3 inches. Seed size and dormancy are the controlling factors for when and where these seeds emerge. Large seeded weeds have greater seed food reserves and can emerge from greater soil depths where moisture is less variable than near the soil surface. Weeds germinate at various times throughout the season depending on environmental cues such as moisture availability and soil temperature. Weeds produce prolific numbers of seeds which may lie dormant for very brief (2 weeks) or long (10-20 years) periods before germination. Weed seeds are distributed by wind, water, birds, and mechanical harvesting equipment.

Pest Distribution and Importance:

Annual grasses infest approximately 98% of all sweet corn acres. Many of these are controlled with preemergence herbicide applications and tillage. While usually not as competitive as broadleaf weed species, annual grasses can reduce crop yields when significant populations are present. This is particularly true in dry years, where competition for moisture early in the season can be critical for sweet corn development.

Foxtails (*Setaria* spp.)

There are three important foxtail species: giant foxtail (*Setaria faberi*), yellow foxtail (*Setaria glauca*), and green foxtail (*Setaria viridis*). At least one of these species can be found in nearly any sweet corn field in the North Central Region. While low populations cause little crop competition, because of seed production an unchecked population can quickly become a severe problem. A primary control method for foxtail spp. is the application of preemergence grass herbicides. These provide early season control, reducing early season competition.

Woolly Cupgrass (*Eriochloa villosa* [Thunb.] Kunth.)

Woolly cupgrass is a relatively new and serious weed problem in the states of Iowa, Illinois, Wisconsin and Minnesota. Its spread has increased rapidly in the last 10 to 15 years. This annual grass weed demonstrates biological, biochemical, and morphological characteristics that make it economically damaging and adds to the difficulty in developing effective management strategies. Woolly cupgrass is a prolific seed producer. This seed tends to germinate earlier and at higher populations than many other annual grass weeds. Woolly cupgrass has demonstrated greater tolerance to most herbicides commonly used for control of annual grasses in sweet corn.

Fall Panicum (*Panicum dichotomiflorum*)

Fall panicum is a summer annual that grows best in warm, wet, fertile soils. The plant tillers profusely and in late August and September the tillers open and scatter hard-coated seeds. These seeds may remain viable for years. Fall panicum is most often a problem in reduced or no-till fields where undisturbed soils favor germination. Fall panicum has shown some tolerance to atrazine, and can be a serious grass weeds in the region.

Wild Proso Millet (*Panicum miliaceum*)

Wild proso millet is a summer annual that tends to be more common in no-till fields and in areas where popcorn and sweet corn production are prevalent. Wild proso millet is one of the most competitive grasses in sweet corn; prolific, late season germinator, natural tolerance to the acetamides, spreading west and south. Its seed matures at sweet corn harvest and is then spread by harvest equipment. Its late germination and partial tolerance to the acetamides makes control difficult. Stale bed and crop rotation aid control.

Barnyardgrass (*Echinochloa crusgalli*)

This summer annual germinates from 0 to 4 inches deep in the soil. The seeds remain viable for several years, and plants may emerge throughout the summer. Barnyardgrass is most troublesome in low, moist, warm soils.

Field Sandbur (*Cenchrus pauciflorus*, also *C. longispinus*)

Field sandbur is a summer annual weed common in sandy soils. The bur of field sandbur can injure scouts and field workers. It is a significant problem in Havana and Manito area (Central IL sands).

Crabgrass spp. (*Digitaria* spp.)

A warm season grass most often troublesome in the southern region of the Corn Belt as well as sandy irrigated areas in MN, WI, and IL. The plants root at the nodes and due to a high root to shoot ratio may be very competitive where moisture is limiting. May be most severe during the late part of the growing season after herbicides have degraded and/or when holes remain in the canopy. Tillage and row cultivation also help control. It is an increasing problem. Crabgrass is tolerant to nicosulfuron, the only postemergence grass herbicide registered in sweet corn.

Shattercane (*Sorghum bicolor*)

Shattercane is an annual grass that is found primarily in cultivated fields where it reseeds itself. Since all sorghums are members of the same species and can hybridize, shattercane is often found in greater populations where sorghums are grown. It is more prevalent in the southern portion of the Corn Belt. Shattercane outcrosses with other sorghum types and is known for developing resistance to ALS type herbicides.

Non Chemical Control

Tillage prior to planting is an important method of annual grass control. Repeated tillage, though not always compliant with conservation tillage practices, may accelerate the reduction of the number of weed seeds from the seed bank in the soil. Row crop cultivation is effective in reducing the impact of weed competition but does not remove enough weeds by itself to result in significantly reduced weed seed numbers in the soil. Other methods of non-chemical control, such as crop rotation, and adjusting planting dates tends to change the relative mix of species in fields but does not significantly reduce competition from annual weeds overall. Field sanitation and the use of certified and clean seed do reduce the spread of many weed species and is always a recommended practice.

Chemical Control

Pre-emergence Control of Annual Grasses:

As noted in the table below, both pre and post emergence herbicides are used for annual grass control. Four classes of herbicide active ingredients are used pre-emergence; triazines (simazine, atrazine), acetamides (alachlor, metolachlor, dimethenamid,), dinitroaniline (pendimethalin), and thiocarbamates (EPTC, butylate). In addition, glyphosate is sometimes used as a burndown herbicide prior to plant, especially on no-till sweet corn. EPTC and butylate have decreased in use for sweet corn production due to increased use of conservation tillage and the availability of other viable options. Neither of these may be available locally and both have been removed from recommendation guides.

Note: Resistance management is a consequence of the herbicide rotations and practices used in field corn and soybean weed management since sweet corn is grown in rotation with these crops. The rotational restrictions of some sweet corn herbicides (esp. atrazine and simazine) limit their usefulness because sweet corn growers need to plant other vegetable crops in subsequent years, which are prohibited. Concern over plant back restrictions for sweet corn is especially acute.

Photosystem II inhibitor (Triazines)

- Atrazine (Many) Enhances tank mix options with grass herbicides but is typically not used as a grass herbicide. The REI is 12hrs and the PHI is 21d.
- Simazine (Princep) Used on sands but is not typically used as a grass herbicide. The REI is 12hrs and the PHI is NA.

Root/shoot inhibitor (Acetamides)

- 42 day residual control. Lose residual control for wild proso millet, woolly cupgrass, and sandbur
- Alachlor (Micro-tech) Leaches in soil. Control is fair to good. On sands may be phytotoxic to sweet corn. The REI is 12hrs and the PHI is 70d.
- Metolachlor (Dual II Magnum). Level of control is good to excellent. Product of choice for grass control. The REI is 12hrs and the PHI is 70d.

- Dimethenamid (Outlook). Level of control is good to excellent. REI is 12hrs PHI is 50d.

Mitosis inhibitor (Dinitroanilines)

- Pendimethalin (Prowl/Pentagon). Hybrid sensitivity, crop tolerance - brittle stalks. Good control on wild proso millet. Lower cost than acetamides. REI is 12hrs and the PHI is 60d.

Shoot inhibitor (Thiocarbamates)

- EPTC (Eradicane) The REI is 12hrs and the PHI is NA due to use at planting. Probably not available throughout much of region.
- Butylate (Sutan Plus) Probably not available throughout much of region. The REI is 12hrs and the PHI is NA due to use at planting.

EPSP synthase inhibition

- Glyphosate (Roundup) Used principally for preplant burndown, stale bed, and post plant spot treatments. Concerns about resistance management as more weeds become resistant. The REI is 4hrs and the PHI is 7d.

Post-emergence Control of Grasses:

ALS inhibitors (Sulfonylureas)

- Nicosulfuron (Accent) Limited to use on selected hybrids of processed sweet corn. OP interactions causes crop injury. Weed resistance with foxtails, shattercane, inherent tolerance of crabgrass. The REI is 4hrs and the PHI is 45d.

Perennial Grasses and Grasslike Weeds

Biology and Life Cycle:

Although perennial grasses and nutsedges produce seed each year the primary mechanism of reproduction is through vegetative propagation.

Tillage can be an effective mechanism of controlling perennial grasses but when done improperly may further distribute the weed throughout the field and exacerbate the problem.

Quackgrass is a cool weather plant and grows aggressively early in the spring and in the fall. The other

perennials listed tend to grow more actively during the late spring and summer.

Pest Distribution and Importance:

Perennial grasses were once a severe problem in sweet corn production prior to herbicides and when pasture was a standard part of the crop rotation. With the introduction of effective herbicides and decline in pasture rotations, many perennial grasses have declined in importance.

Quackgrass (*Elytrigia repens*)

Quackgrass is a perennial grass that spreads by rhizomes. These rhizomes are effectively spread by tillage, increasing the distribution of the population in a field. Tillage is an effective control by depleting food reserves and bringing rhizomes to the surface. Overall this weed is decreasing in importance.

Wirestem muhly (*Muhlenbergia frondosa*)

Wirestem muhly is a perennial grass that reproduces by seeds and underground rhizomes. It is native to the Midwest. It was not considered a common row crop weed until the 1950's when serious infestations developed in cultivated fields. Delayed seedbed preparation will help control wirestem muhly in sweet corn by bringing rhizomes to the soil surface to dry out. This weed is on the increase.

Johnsongrass (*Sorghum halepense*)

Johnsongrass produces large rhizomes that can be spread throughout the field making it difficult to contain and control. Johnsongrass is more common in the southern portions of the Corn Belt and is a serious problem south of I-70. Johnsongrass is also a reservoir for Maize Dwarf Mosaic Virus.

Yellow Nutsedge (*Cyperus esculentus*)

Yellow nutsedge causes the most severe perennial weed infestations and is quite serious across the region. It reproduces from tubers as the seed does not survive overwintering, and tubers can adapt to almost any soil type and conditions. Tubers germinate at depths of up to 12 inches and may remain viable for up to three years in many soils.

Non Chemical Control

Tillage prior to planting tends to reduce the growth of some perennial weeds that germinate early (i.e. nutsedge). Repeated tillage, though not always compliant with conservation tillage practices, is sometimes the only effective method of perennial weed control. Row crop cultivation may also impact perennial weeds and reduce weed competition. Other methods of non-chemical control, such as crop rotation with perennial crops, and adjusting planting dates can seldom be used in the Midwest. Field sanitation does reduce the introduction of some perennial weed species and is always a recommended practice.

Chemical Control

Pre-emergence control of perennial grasses:

Suppression of nutsedges, and perennial grasses is effected with the use of EPTC or butylate, where available. In addition, nutsedge can be suppressed by the acetamide herbicides. Roundup can also be used if the grasses are present in the field and growing prior to planting or if the grasses are actively growing after the crop is removed. For quackgrass, nutsedge, and Johnsongrass, tillage is useful.

Shoot inhibitor (Thiocarbamates)

- EPTC (Eradicane). Not generally available. Doesn't have good perennial activity. The REI is 12hrs and the PHI is NA due to use at planting.
- Butylate (Sutan Plus) Not generally available. Doesn't have good perennial activity. The REI is 12hrs and the PHI is NA due to use at planting.

EPSP synthase inhibition

- Glyphosate (Roundup) Must be applied post emergence, either before planting or after harvest. The REI is 4hrs and the PHI is NA due to use before planting.

Post-emergence control of nutsedge and perennial grasses:

Post emergence and perennial grass control is generally achieved by the use of nicosulfuron. As indicated below, specific products may cause crop injury and may not be used where certain OP insecticides have been applied. Nutsedge may be controlled by halosulfuron, bentazon, or bentazon plus atrazine.

ALS inhibitors (Sulfonylureas)

- Halosulfuron (Permit, Sandea). Level of control is good on Nutsedge. Significant risk of crop injury depending on hybrid. OP interaction causes crop injury. The REI is 12hrs and the PHI is 30d.
- Nicosulfuron (Accent) Limited to processed sweet corn. Crop injury risk depending on hybrid. OP interaction results in crop injury. The REI is 4hrs and the PHI is 45d.

Photosynthetic Inhibitor

Basagran (Bentazon). Mainly nutsedge control. No perennial grass activity. Good crop safety. The REI is 12hrs and the PHI is 30d.

Annual Broadleaf Weeds

Biology and Life Cycle:

Broadleaf weeds germinate at soil depths from 1/8th of an inch to 3 or 4 inches. Seed size and dormancy are the controlling factors for when and where these seeds emerge. Large seeded broadleaf weeds have greater seed food reserves and can emerge from greater soil depths where moisture is less variable than near the soil surface. Weeds germinate at various times throughout the season depending on environmental cues such as moisture availability and soil temperature. Weeds produce prolific numbers of seeds which may lie dormant for very brief (2 weeks) or very long (30-50 yrs) periods before germination. Weed seeds are distributed by wind, rain, birds, and mechanical harvesting equipment.

Pest Distribution and Importance:

Each of the weeds listed below has its own distribution range and importance. The importance of various weeds is highly dependent upon the prevailing attitudes and herbicide use practices. As herbicide use patterns change weed species change as well.

Eastern Black Nightshade (*Solanum ptycanthum*) & **Hairy nightshade** (*S. sarrachoides*)

This summer annual can produce thousands of berries; each berry contains up to 50 seeds. While nightshade is generally not considered a serious pest in the Corn Belt, severe infestations in individual fields do occur. Tillage and row cultivation are effective for early, newly emerged seedlings.

Common Cocklebur (*Xanthium strumarium*)

Common cocklebur is a summer annual weed. Its seeds are spread by attaching to animal fur or by tillage or harvesting equipment. Cocklebur is a serious competitor for moisture. Cultivation and tillage will all help to control cocklebur establishment.

Common Lambsquarters (*Chenopodium album*)

Common lambsquarters produce numerous small seeds which germinate after an overwintering process. Optimal temperature for germination is 70F, but can germinate between 40 to 94, which suggests early germination capabilities. Survival is favored by rains that dilute or leach herbicides from the soil surface.

Common Ragweed (*Ambrosia artemisiifolia*)

Common ragweed is a summer annual that is favored by moist soils and can be a serious problem in individual fields. Control of common ragweed with tillage or row cultivation is effective in controlling small seedlings. More serious in sands.

Giant Ragweed (*Ambrosia trifida*)

Wet weather favors giant ragweed, and this summer annual may be a severe problem in isolated fields.

The seeds of giant ragweed may remain viable in the soil for several years. Small seedlings can be controlled with row cultivation and tillage. This weed is more serious in sands.

Jimsonweed (*Datura stramonium*)

Jimsonweed produces several hundred hard-coated seeds per plant that may remain viable in the soil for years. This summer annual grows best under warm temperatures and moist soils. Jimsonweed infestations harm soybean crops via competition for water, especially in dry years. The shade of its leaves in shorter crops increases yield loss due to decreased nutrient uptake. Jimsonweed also contains the alkaloids, atropine, hyoscyamine, and hyoscyne, which are toxic. Even small amounts of jimsonweed can cause harvest problems.

Kochia (*Kochia scoparia*)

Kochia is similar to common lambsquarters in many respects. It produces numerous small seeds and can germinate early in the season. Kochia has also developed resistance to a number of herbicides including triazines and ALS compounds. Although not distributed as widely as lambsquarters, kochia has been expanding from small infestations started along rail and road systems where seed has been carried in.

Morningglories (*Ipomoea* spp.)

Tall morningglory and ivyleaf morningglory are the two major annual morningglory species found in the Corn Belt. The seeds of these summer annuals may survive for several years in soil. Infestations are most common in moist soils along river bottomland, but these plants can be found mid-IL and south. Annual morningglories adapt to crops by vining about the crop, so shading by the canopy is not particularly successful in reducing growth. Newly emerged seedlings can be controlled by tillage and cultivation, but this may result in conditions that favor emergence by weeds deeper in the soil profile. After vines begin to twine about the stems of the crop, cultivation may not be as effective.

Pennsylvania Smartweed (*Polygonum pensylvanicum*)

This summer annual grows best on wet soils and is widely distributed across the Midwest. Smartweed emerges early in the spring and can be a severe problem if tillage is delayed to wet soils, as seedbed preparation may result in transplanting larger plants rather than destroying them.

Pigweeds (*Amaranthus retroflexus*, *A. hybridus*, *A. powellii*)

Pigweeds are prolific seed producers, and one plant can produce over 100,000 seeds in one growing season. The seeds of this plant may remain viable for years. Pigweeds are a problem in no-till systems because undisturbed soils favor germination of the minuscule seeds, and the debris keeps the field moist and allows for extended germination. Other favorable germination locations are where excess nitrogen is available, and where no soil applied herbicides have been used. Localized populations of some biotypes of pigweed have shown triazine or acetolactate synthase (ALS)-inhibitor resistance.

Velvetleaf (*Abutilon theophrasti*)

Velvetleaf is the most significant annual broadleaf weed in most sweet corn production and is most damaging in the central part of the region. Velvetleaf is a serious competitor for moisture in drought

conditions. Cultivation can partially control velvetleaf when used in the early season.

Waterhemp (*Amaranthus tuberculatus*, *A. rudis*)

Common waterhemp is a native species and is a serious weed problem throughout the Corn Belt. Changes in agricultural practices that favor this weed include reductions in tillage, herbicide selection, simplified crop rotations, and recent weather patterns. There are also many indigenous factors that have contributed to the increase in common waterhemp populations. These include seedling emergence late in the growing season, high seed production and an ability to germinate from shallow soil depths. Control of common waterhemp has become increasingly difficult due to resistance to many common herbicides. Waterhemp has demonstrated cross-resistance to herbicides with the ALS inhibition mode of action, as well as to triazine compounds. Waterhemp is perhaps the most serious weed of this group in terms of difficulty to control and overall impact on crop yields.

Non Chemical Control

Tillage prior to planting is an important method of annual broadleaf control. Repeated tillage, though not always compliant with conservation tillage practices, may accelerate the reduction of the number of weed seeds from the seed bank in the soil. . Row crop cultivation is effective in reducing the impact of weed competition but does not remove enough weeds by itself to result in significantly reduced weed seed numbers in the soil. . Other methods of non-chemical control, such as crop rotation, and adjusting planting dates tends to change the relative mix of species in fields but does not significantly reduce competition from annual weeds overall. Field sanitation and the use of certified and clean seed do reduce the spread of many weed species and is always a recommended practice.

Chemical Control

Pre-emergence control of annual broadleaf weeds:

Soil applied herbicides need to be in place and evenly distributed throughout the top 1 to 2 inches of soil at the time of weed emergence for adequate uptake and maximum effect. Under conditions of high rainfall many pre-emergence herbicides may be too diluted or leached out of this soil zone and rendered ineffective. Under very dry conditions, pre-emergence herbicides may not have been leached into the soil far enough to have the substantial contact necessary for weed death.. Large seeded broadleaf weeds like velvetleaf and giant ragweed are difficult to control with preemergence herbicides. Other broadleaf weeds produce small seeds, such as pigweeds, lambsquarters, kochia, and nightshade. Many of these weeds germinate throughout the season in response to soil wetting provided by occasional rainfall. Pre-emergence herbicides, which have short soil persistence, may not adequately control the late flushes of germinating weeds.

Photosystem II inhibitor (Triazines)

- Resistance management problems - 4-5 weeds have been identified as resistant already
- Atrazine (Many) At current use rates does not provide season long broadleaf control. Atrazine rates are restricted to below federal use rates in some Wisconsin areas. Enhances tank mixes, provides consistency in tank mix. High frequency of use, especially after loss of Bladex. The REI is 12hrs and the PHI is 21d.
- Simazine (Princep) Mainly used for sandbur control. Rotational restrictions limit its use. The REI is 12hrs and the PHI is NA due to use at planting.

Root/shoot inhibitor (Acetamides)

- Contributes to control of some small seeded broadleaf weeds, not principally broadleaf herbicides.
- Alachlor (Micro-tech, Lasso). The REI is 12hrs and the PHI is NA due to use at planting.
- Metolachlor (Dual II Magnum) The REI is 12hrs and the PHI is NA due to use at planting.
- Dimethenamid (Outlook). The REI is 12hrs and the PHI is NA due to use at planting.

Mitosis inhibitor (Dinitroanilines)

- Pendimethalin (Prowl/Pentagon). Not principally a broadleaf herbicide but contributes to control. Better control of lambsquarters than acetamides. Crop tolerance is marginal. The REI is 12hrs and the PHI is NA due to use at planting.

Post-emergence control of annual broadleaf weeds:

As mentioned above, several flushes of broadleaf weeds can occur throughout the season. Although there are no post-emergence broadleaf herbicides with true "residual" activity some herbicides do provide a modicum of control through soil activity. These herbicides include post applications of atrazine. Though the trend for increasing use of post applied herbicides continues, concerns about crop injury and drift to off-target crops or plants remains a hindrance. A new product and new chemistry is Callisto (mesotrione). Since it is newly registered for field corn less is known of the advantages and disadvantages for sweet corn other than it has potential for broadleaf weed control. However, new chemistries are always welcome from the perspective of managing resistant weed development.

Growth Regulator

- 2,4-D (Many). Crop tolerance limits its use. Export restrictions limit its use. Used mainly as a burndown. Some formulations have better safety tolerance. The REI is 48hrs and the PHI is 45d.

ALS inhibitors (Sulfonylureas)

- OP interactions. Resistance problems with waterhemp, ragweeds, kochia.

- Nicosulfuron (Accent) Limited broadleaf spectrum. Crop injury may occur. The REI is 4hrs and the PHI is 45d.
- Halosulfuron (Permit, Sandea). Limited Broadleaf spectrum, not effective on lambsquarters or nightshade. Good on velvetleaf, pigweeds, ragweeds. Not effective on lambsquarters. Crop injury may occur. The REI is 12hrs and the PHI is 30d.

Photosystem II inhibitors

- Bentazon (Basagran, in Laddok) Level of control is good on velvetleaf and cocklebur. When combined with atrazine its good on broad spectrum of broadleaf weeds. The REI is 12hrs and the PHI is 30d.

PPO Inhibitor

- Carfentrazone (Aim). Control of velvetleaf is excellent. Control of pigweeds, nightshade is good. Risk of crop injury. The REI is 12hrs and the PHI is not indicated.

EPSP synthase inhibition

- Glyphosate (Roundup) Used for burndown preplant or stale seedbed treatment. Spot treatment label. Resistance management concerns. The REI is 4hrs and the PHI is NA due to use before planting or after harvest.

Perennial broadleaf weeds

Biology and life cycle:

While perennial weeds do produce seeds, the majority of plants listed propagate through vegetative means. Most perennial weeds begin growth early in the season before crops are planted and may also have a very active period of growth after the crop has been harvested. Tillage can be effective for controlling many perennial weeds but it may also distribute viable rhizomes, roots, and tubers throughout the field if done improperly.

Pest Distribution and Importance:

The occurrence of perennial broadleaf weeds is highly dependent on the tillage regime used in sweet corn production. Since most perennial broadleaf weeds do not tolerate tillage, these weeds are more of a problem in reduced tillage and no-till operations.

Common Milkweed (*Asclepias syrica* L).

This perennial weed reproduces by seeds and adventitious buds that sprout from underground roots.

Seedlings produce vegetative buds 18-21 days after germination, and seeds may remain viable for up to three years. Seeds may germinate from as deep as 2 inches in the soil, and undisturbed fields or fields with reduced tillage and moist soils are favored. Problems with common milkweed have been increasing due to the decrease in tillage and row cultivation.

Canada thistle (*Cirsium arvense*)

Canada thistle is a perennial weed with a vigorous, rhizome-like root system. Propagation is by rootstock and seeds; only female plants produce seed. Preplant tillage and row cultivation can control small seedlings but are less effective in controlling plants arising from rootstocks.

Field bindweed (*Convolvulus arvensis*) and hedge bindweed (*Calystegia sepium*)

These weeds are vining weeds commonly found in both cultivated and no-till fields. These weeds can rapidly engulf sweet corn rows in vines reducing sweet corn growth and yield. The extensive mass of vines also makes harvest very difficult.

Hemp dogbane (*Apocynum cannabinum*)

This perennial weed is capable of regrowth from perennating rootstock within six weeks of emergence. The underground root system may extend laterally 20 feet per year and downward as far as 14 feet. The central portion of the Corn Belt is usually most severely infested with dogbane. Tillage can reduce dogbane infestations, but is ineffective once populations are established.

Swamp smartweed (*Polygonum coccineum* Muhl. ex Willd)

Swamp smartweed is commonly found in low, wet areas of fields. Because of an extensive root system it is a strong competitor with sweet corn and difficult to eradicate. Because of its similarity to Pennsylvania smartweed, an annual, many producers incorrectly identify this weed.

Bigroot Morningglory (*Ipomoea pandurata*)

Bigroot morningglory is becoming more common. It produces a tuber that can reach eight inches in diameter and several feet deep. When the new vines emerge they are purplish in color. Control almost invariably will require many repeated treatments. A very serious problem in Wabash Valley.

Pokeweed (*Phytolacca americana*)

Pokeweed is becoming more important as a weed throughout the eastern section of the Corn Belt. It tends to be hard to kill.

Horsenettle

Horsenettle is on the increase due to an increase of minimal tillage. Becomes a rotational problem with other vegetable crops. It is a reservoir for viruses in other vegetables.

Dandelion

Difficult to control with burndown treatments in reduced tillage. Growth regulator herbicides are useful for control.

Non Chemical Control

Tillage prior to planting tends to reduce the growth of some perennial weeds that germinate early. Repeated tillage, though not always compliant with conservation tillage practices, is sometimes the only effective method of perennial weed control. Row crop cultivation may also impact perennial weeds and reduce weed competition. Other methods of non-chemical control, such as adjusting planting dates, can seldom be used. Field sanitation does reduce the introduction of some perennial weed species and is always a recommended practice. Timing is critical, if done improperly tillage may result in the spread of rhizomes or root stock and proliferate the problem. Tillage opens up soil on heavy soils. Moldboard plow is an option in some instances that will help control weeds. What weed species are present depends on rotation regimes within area where sweet corn is planted.

Chemical Control

Pre and Post emergence control of perennial broadleaf weeds:

While much of the effort to control perennial weeds takes place before the crop is planted or after it has been harvested, effective control of perennial weeds often necessitates control efforts during the cropping season as well. The control ratings for some of the more common perennial broadleaf weeds are included in a table at the end of this section. Other perennial broadleaf weeds than those listed above, such as Jerusalem artichoke may also be present in some fields, but are less prevalent. The control ratings given for perennial weeds tend to be more subjective than those for annual weeds. For example, although a rating of "Good" for control of an annual weed typically suggests 85 percent or better control of a weed, a rating of "Good" for perennial weeds might indicate anywhere from 60% to 90% dieback. The variability in rating perennial weeds arises from the fact that there are fewer studies to determine control, there are fewer products and control measures available with which to compare, and that perennial weeds typically re-sprout from root stock soon after dieback. It is generally agreed that multiple treatments in a season, which include a combination of herbicides and mechanical means of control, are necessary to reduce perennial weed populations and obtain what is otherwise termed "Good" control. It is also difficult to get good control of perennial broadleaf weeds because herbicides can not be applied at optimal stage of growth.

EPSP synthase inhibition

- Glyphosate (Roundup). Level of control is fair for common milkweed, hemp dogbane, and swamp smartweed. Level of control is good for Canada thistle and field bindweed control. Spot treatment, burndown preplant, or stale bed only. Marginal on dandelion for burndown treatments. The REI is 4hrs and the PHI is NA due to use before planting or after harvest.

Growth Regulator

- 2,4-D (Many) Burndown (preplant only) due to crop sensitivity. Level of control is marginal at labeled rates. The REI is 48hrs and the PHI is 45d.

Photosynthetic inhibitors

- Bentazon (Basagran, in Laddok) Level of control is fair for some species, may have to treat more than once. The REI is 12hrs and the PHI is 30d.

Winter Annual Weeds and Cover Crops

Biology and life cycle:

Winter annual weeds start their growth in the fall and complete their life cycle in the spring, often bearing seed in May or June. While discing, plowing, or field cultivation tillage is effective for all winter annuals, no-till and conservation tillage fields must rely on herbicides for control. Heavy populations of winter annual weeds can sap the moisture from the soil and slow or reduce germination of the crop.

Pest Distribution and Importance:

A number of winter annual weeds can be present in fields throughout the Midwest with the most common of these being henbit and chickweed. Some winter annuals are more prevalent across the northern portion of the Corn Belt, while others such as annual bluegrass and annual brome-species tend to be more of a problem across the southern section of Missouri, Illinois, Indiana and Ohio. Weeds present in the field early in the season may attract damaging insects and provide an environment for egg laying.

Common Chickweed (*Stellaria media*)

A common weed which produces prolific amounts of seed and a thick mat of low vegetative growth. Can remove much soil moisture and, if untreated, can seriously affect crop establishment and growth in dry years.

Horseweed (Marestail) (*Conyza canadensis*)(previously *Erigeron canadensis*)

This weed is becoming much more common throughout the Midwest due to reduced tillage. It produces a large amount of seed that is wind borne. Resistant biotypes of this weed to glyphosate have been identified. Reservoir of viruses.

Henbit (*Lamium amplexicaule*)

This plant is a low growing (5 to 9 inches) winter annual. It can produce a thick mat of growth early in the season and pull needed moisture from the soil.

Mustards

Mustard species include field pennycress (*Thlaspi arvense*), wild mustard (*Brassica kaber*), tansy mustard (*Descurainia pinnata*), shepherd's-purse (*Capsella bursa-pastoris*), yellow rocket (*Barbarea vulgaris*), and the pepperweeds (*Lepidium* spp.) Although a number of herbicides may control some mustard species, the presence of mature (large) mustards in the fields early in the season often limits which herbicides may be applied. Though usually less aggressive than henbit and common chickweed in terms of population expansion, they are serious competitors with crops.

Brome grasses (*Bromus* spp.)

Brome grasses include downy brome, Japanese brome, and cheat. If left uncontrolled these grasses will continue to pose a competitive threat to the crop.

Bluegrass (*Poa annua*)

Bluegrass can become more of a problem under continuous no-till. Although populations do not grow at an explosive rate, control without tillage can be difficult.

Grass Cover Crops

Grass cover crops include winter annual grains planted to protect the soil and build soil tilth and at times, more established sods from conservation plantings being converted to cropland. The former may include barley, rye, and wheat while the latter may include ryegrass, orchardgrass, perennial brome grasses, fescue and timothy.

Non Chemical Control

Tillage prior to planting effectively eliminates competition from winter annual weeds. However, tillage is not always compliant with conservation tillage practices. Tillage opens up soil on heavy soils. Moldboard plow is an option in some instances that will help control weeds. What weed species are present depends on rotation regimes within area where sweet corn is planted.

Chemical Control

The following herbicides are commonly used for burndown of winter annual weeds or cover crops. Various combinations of these products may be used depending on the weed species present and the size of the weeds.

Photosystem II inhibitor (Triazines)

- Atrazine (Many) The REI is 12hrs and the PHI is 21d. Level of control is good.
- Simazine (Princep) Level of control is fair to good. The REI is 12hrs and the PHI is NA due to use before planting.

EPSP synthase inhibition

- Glyphosate (Roundup) Burndown and preplant only. Horseweed (maretail) resistance is becoming common. The REI is 4hrs and the PHI is NA due to use before planting or after harvest. The level of control is good.

Growth Regulator

- 2,4-D (Many) Preplant and burndown only. The REI is 48hrs and the PHI is 45d. The level of control is good.

Photosystem I

- Paraquat (Gramoxone Max). Burndown only. The REI is 48 hrs and the PHI is NA due to use before planting. The level of control is good.

Herbicide Resistant Weeds

A number of weed biotype populations have been identified as having resistance to one or more herbicide classes. Those most commonly found are **waterhemp, lambsquarters, kochia, and pigweeds**. In addition, resistant biotypes of **common and giant ragweed, cocklebur, shattercane, velvetleaf, horseweed (maretail)** and **giant foxtail** have been found in some areas. The herbicide modes of action that have resulted in the most rapid development of resistant populations include those that have been used with the greatest frequency for weed control in corn and soybeans. This would include the triazines (translocated photosynthetic inhibitors) and the ALS inhibitors (sulfonylureas and imidazolinones). There is considerable concern about the potential development of resistance to glyphosate as it also has become widely used within the last 5 years. Both horseweed and waterhemp have shown resistance to glyphosate in the Midwest. The difficulty in dealing with herbicide resistant weeds is often that the presence of such weeds necessitates the use of a more robust and more expensive approach to weed control. Since whole groups of compounds are no longer effective many individual products within those groups will no longer be efficacious. Control often rests on a strategy of crop rotation (to permit rotation of herbicides) and herbicide combinations. The development of resistant weed biotypes can be delayed or postponed indefinitely through the proper selection of herbicides, tillage, and equipment and field sanitation. Resistance management is mainly a field corn and soybean issue. **See notes previous.**

Table 2. Estimates⁴ of Crop Loss and % Crop Area Infested by Weeds

Weed Name	Scientific Name	% Acres Infested at any level	% Loss* on area infested	Avg Loss %
Barnyardgrass	Echinochloa crusgalli	15	4.5%	0.675
Eastern black nightshade	Solanum ptycanthum	30	0.7%	0.21
Common cocklebur	Xanthium strumarium	50	0.5%	0.25
Common lambsquarters	Chenopodium album	90	1.8%	1.62
Common milkweed	Asclepias syrica .	10	11.9%	1.19
Common ragweed	Ambrosia artemisifolia	60	0.5%	0.3
Crabgrass	Digiteria spp.	60	0.5%	0.3
Fall panicum	Panicum dichotomiflorum	60	3.2%	1.92
Foxtail species	Setaria spp.	95	0.6%	0.57
Giant ragweed	Ambrosia trifida	70	5.2%	3.64
Jimsonweed	Datura stramonium	40	0.5%	0.2
Morningglory	Ipomoea spp.	40	0.5%	0.2
Pigweed spp.	Amaranthus spp.	90	0.5%	0.45
Shattercane	Sorghum bicolor	20	1.1%	0.22
Velvetleaf	Abutilon theophrasti	60	5.6%	3.36
Wild proso millet	Panicum miliaceum	30	2.5%	0.75
All Weeds				15.855

Table 3. Estimates⁴ of Herbicide Application rate and area treated for 2003.

Herbicide	Area Applied (%)	Rate/ Application (Lbs/acre)
Atrazine	95	1.07
Metolachlor	35	2.14
Alachlor	10	2.06
Dimethenamid	40	1.17
Bentazon	15-20	.44
Glyphosate	1-5	.51

Nicosulfuron	25-45	.03
2,4-D	10	.35
Simazine	1	1.39
EPTC	<1	3.0
Butylate	<1	4.0
Carfentrazone	25 -45	.008

Table 4. Herbicide Rates, MOA, REI, PHI and Primary Target

Trade Name	Common Name	Product rates low.....hi	Unit rate	MOA	REI hrs	PHI days	Primary Target
Preemergence							
AAtrex 4L	atrazine	3.2---4	pt		12	21	
AAtrex Nine-O	atrazine	1.8---2.2	lb		12	21	
Dual Magnum	s-metolachlor	1.0---3	pt			70	Grass/ BL
Eradicane Extra 6.7EC	EPTC+safener +extender	4---8	pt		12	70	Grass/ BL
Outlook 6EC	dimethenamid	10---21	fl oz		12	50	Grass/ BL
Lasso 4EC	alachlor	2---4	qt		12	70	Grass/ BL
Prowl 3.3EC	pendimethalin	1.2---3.6	pt		24	70	Grass/ BL
Sutan 6.7EC	butylate +safener	2.5---3.5	qt			70	Grass
Postemergence							
2,4-D amine	2,4-D	0.5---1	pt		48	45	BL
AAtrex 4L	atrazine	1---1.5	pt		12	21	
AAtrex 80WP	atrazine	0---1.8	lb		N/ A	21	
AAtrex Nine-O	atrazine	0---1.6	lb		12	21	

Accent 75SP	nicosulfuron	0---0.6	oz		45	Grass/ BL
Basagran 4S	bentazon	1.5---2	pt	12	30	BL
Stale seedbed						
Roundup Ultra	glyphosate	1.5---2	pt	4	80	Grass/BL

Insect Pests

The most important pests in sweet corn cause damage to ears; European corn borer, corn earworm, western bean cutworm, and fall armyworm. An early season pest is the black cutworm, although cutworm infestations tend to be more sporadic than the ear-invading pests. The corn flea beetle can be a problem on some hybrids, as a vector of Stewart's bacterial wilt early in the season (5). Corn grown under contract for processing has allowable damage of 5-20% of the ears, depending on the severity, before grade is lowered. Fresh market sweet corn has a much lower tolerance for damage; fewer than one out of twenty ears (<5%) arriving at the point of sale can exhibit injury. Most contract growers depend heavily on crop scouting and monitoring traps, both pheromone and blacklight, to aid in decision making regarding insecticide application. In a typical year, the major insect pests cause severe economic damage on 15% or more of the total acreage. There are several types of injury inflicted by these pests and occurrence and damage severity can vary significantly by year and region. Insect resistance to insecticides is an ever-present issue. European Corn Borer is probably the most significant pest of sweet corn in the North Central States production area. Corn earworm is the target of repeated pesticide applications throughout the growing season and is associated with resistance management techniques in sweet corn. However, migratory insects from cotton and (perhaps) field corn insecticide treatments may be the major source of resistance concern. As mentioned previously, planting dates are often staggered to permit market delivery of sweet corn over a greater length of time. Altering planting dates may also improve insect pest management but it is not practical due to market window demand.

Table 5. Estimates⁴ of Crop Loss and % of Area Infested by Insects

Common Name	Scientific Name	% Acres Infested*	% Loss on infested area*	Avg loss %
Black Cutworm	Agrotis ipsilon	5	35	1.7

Corn Earworm	Helicoverpa zea	4	90	3.6
		50 **	25	12
Corn Leaf Aphids	Rhopalosiphum maidis	12	15	1.8
Corn Rootworm, Northern	Diabrotica barberi			0
Corn Rootworm, Western	Diabrotica virgifera	>1	95	0.4
European Corn Borer	Ostrinia nubialis	2	100	2.2
		70**	10**	7**
Fall Armyworm	Spodoptera frugiperda	2	66	1.4
Flea Beetles	Disonycha triangularis			0
Japanese Beetle	Popillia japonica			0
Sap Beetle	Carpophilus lugubris (Murray)			0
All insects				11

*Based on U.S. Averages

** Fresh market estimation

Germination and Emergence

Seedcorn Maggot (*Delia platura*)

Biology and Life Cycle:

The seedcorn maggot is the larva of a small fly. The flies are attracted to fields where relatively fresh animal manure, green manure and other organic material are present. Seedcorn maggots seek out germinating soybean and corn seeds and eat the germ, killing the plant. Rescue treatments are not available for control of seedcorn maggot. Therefore, most treatments are made in anticipation of problems or replant situations.

Pest Distribution and Importance:

Overall, seedcorn maggots are considered a minor pest in corn production. This pest tends to be 'spotty' in an infested field. Growers may be controlling seedcorn maggot with soil insecticides applied for

rootworm, wireworms, etc.

Chemical controls:

- **Organophosphate + Organochlorine**

- Lindane+diazinon (Kernel Guard, Agrox, others) as a seed box treatment. Level of control is good. The REI is 48hrs and the PHI is NA due to use as soil/seed treatments.

- **Organophosphate**

- Terbufos (Counter). Level of control is good. The REI is NA and the PHI is NA due to use as soil/seed treatments.
- Chlorethoxyfos (Fortress). Level of control is good. The REI is NA and the PHI is NA due to use as soil/seed treatments.

- **Organophosphate + pyrethroid**

- Tebupirimphos+cyfluthrin (Aztec). Level of control is good. The REI is NA and the PHI is NA due to use as soil/seed treatment.

- **Carbamates**

- Carbofuran (Furadan). Level of control is good. The REI and the PHI are NA due to use as soil/seed treatment.

- **Pyrethroids**

- Tefluthrin (Force ST). Level of control is good. The REI is NA and the PHI is NA due to use as soil/seed treatment.
- Bifenthrin (Capture). Level of Control is good. The REI is NA and the PHI is NA due to use as soil/seed treatment.
- Tefluthrin (Force 3G). Level of control is good. The REI is NA and the PHI is NA due to use as soil/seed treatment.

- **Neonicotinoids**

- Imidacloprid (Gaucho, Gaucho Extra, and Prescribe). Level of control is good. The REI and the PHI is NA for soil/seed treatment.

- **Other Pest Management aids:**

Later planting may accelerate crop growth and help avoid damage but is usually not a practical solution. Field sanitation techniques, such as clean tillage may help to reduce insect damage, but is usually not a practical solution.

True White Grub [*Phyllophaga* sp.],
Wireworm [*Melanotus* sp.]
Japanese Beetle Grub [*Popillia japonica*]
Grape Colaspis
Seed Corn Beetle

Biology and Life Cycle:

These insects attack the germinating corn seed or feed on roots. Generally, infestations are patchy in fields and depending on species, damage may recur in succeeding years. Rescue treatments are not available for control of these pests, therefore most treatments are made in anticipation of problems or replant situations.

Pest Distribution and Importance:

These pests are of moderate importance to sweet corn production, though they are becoming more prevalent. Wireworms are perceived by producers to be more of a problem west of the Missouri River and in the Wabash Valley. White grubs have historically been worse after sod and may be more of a problem where forages are included in rotation with corn (species dependent). White grubs tend to be more problematic in earlier planted corn and control is dependent on the number of grubs present. White grubs have a three year life cycle and are harder to control in the more mature stages (3rd yr) year.

Annual white grubs rarely cause economic damage to sweet corn.

Chemical controls:

- **Organophosphate**

- Terbufos (Counter). Level of control is good. The REI is NA and the PHI is NA for soil/seed treatment.
- Chlorethoxyfos (Fortress). Level of control is good. The REI and the PHI is NA for soil/seed treatment.
- Chlorpyrifos (Lorsban) Level of control is good. The REI is NA and the PHI is 35d.

- **Organophosphate + Organochlorine**

- Lindane+diazinon (Kernel Guard). Seed box treatment. Level of control is good. The REI is NA and the PHI is NA for soil/seed treatment.

- **Pyrethroids**

- Permethrin (Kernel Guard Supreme). Level of control is good. The REI is and the PHI is Not applicable for soil/seed treatment.
- Tefluthrin (Force 3G). Level of control is good. The REI is 0hrs and the PHI is NA for soil/seed treatment.
- Bifenthrin (Capture). Level of control is good. The REI is NA and the PHI is NA for soil/seed treatment.

- **Neonicotinoids**

- Imidacloprid (Gaucho, Gaucho Extra, and Prescribe). Level of control is good. The REI is NA and the PHI is NA due to use as soil/seed treatment.

- **Other Pest Management aids:**

- Good grass weed control reduces wireworm problems. Field sanitation has little effect for these insects.

Vegetative Stages

Corn Rootworm (western [Diabrotica virgifera virgifera] and northern [D. Barberi])

Biology and Life Cycle:

Adults feed on silks, sometimes inhibiting pollination, and lay eggs in late summer and early fall which hatch in early June of the following year. Corn rootworm (CRW) larvae feed on a narrow range of host species. In general, a corn-soybean rotation disrupts their life cycle and constitutes the most effective management tool available for many farmers. Larvae are the most destructive stage of the corn rootworm. Larvae overwinter in soil and begin to develop in the spring, going through three instars while feeding on corn roots. Corn rootworm larvae prune the roots by chewing on the root surface and by tunneling inside during the summer months.

The corn rootworm complex has two species which are significant to corn production in the Midwest: Northern corn rootworm (*D. barberi* Smith & Lawrence), and Western corn rootworm (*D. virgifera virgifera*). Some populations of NCR have shown a life cycle adaptation called extended diapause. Extended diapause occurs when some of the eggs rest through the next summer and hatch the second

spring after being laid. With extended diapause, control by a corn-soybean rotation can fail. This is currently occurring in parts of Minnesota, Iowa, South Dakota, Illinois, Indiana, (and to a lesser extent) Michigan and Ohio, and has resulted in a change in the dynamics of insecticide use in those areas. Recently, populations of WCR have lost a preference to lay eggs in corn, and prefer to lay eggs in other non-corn crop fields, such as soybean. This phenomenon occurs in northern (near the Wisconsin border) and east-central Illinois, northern Indiana, northwestern Ohio, and in southern Michigan. With WCR soil-applied insecticide treatments are generally a standard practice in corn acreage following corn and non-corn crops that target the larvae. A corn-soybean rotation may fail to control rootworms when volunteer corn plants in a soybean field attract egg-laying beetles.

Pest Distribution and Importance:

This pest has significant importance to corn production. Rootworm tolerant transgenic hybrids may become available in near future, but are targeted to control only rootworms. As a result, they may not reduce the overall perceived risk of insect complexes and associated pesticide use. Rootworm insecticides are applied in furrow or in bands. Rootworms survive in the untreated areas, therefore allowing part of the field to remain untreated has relieved the resistance problems. Foliar broadcast applications targeted against adult rootworms have been used in the western Corn Belt in addition to in-furrow or band applications. Less than 10% acres treated, some economic loss when populations are high. Western corn rootworm variant causing problems - adults laying eggs in soybeans (rotational crop for nitrogen supplier). There are also documented cases after wheat and alfalfa. Sweet corn has a weaker root system so CRW causes more problems than in field corn. Adult beetle also clips silks, later planted sweet corn attractive to beetles. Beetles leave field corn and move into sweet corn (late planted - after June 1). Soil type makes a difference - sandy soils have less of a problem.

Chemical treatments: (Soil-applied insecticides for larval control)

- **Organophosphates -**

- Worker safety issues, odor issues (stinks), chronic exposure can cause health problems.
- Terbufos (Counter CR) @ 6 ounces per 1,000 ft. of row. Level of control is good. Interaction with some herbicides, Accent primarily, will cause crop injury. Worker safety issues. The REI is and the PHI is NA due to use as soil/seed treatment.
- Chlorpyrifos (Lorsban 15G) @ 8 ounces per 1,000 ft. of row. Level of control is fair to good. The REI is NA and the PHI is NA due to use as soil/seed treatment.

- **Phorate (Thimet 20G) @ 6 ounces per 1,000 ft. of row. Level of control is not available. Worker safety issues. The REI is and the PHI is NA due to use as soil/seed treatment.**

- Chlorethoxyphos (Fortress 5G) @3.25 ounces per 1,000 ft of row in 30 inch -row spacings. Level of control is poor. The REI is NA and the PHI is NA due to use as soil/seed treatment.

- **Organophosphate + Pyrethroid**

- Tebupirimphos+cyfluthrin (Aztec 2.1G) @ 6.7 ounces per 1,000 ft. of row. Level of control is good. Its two modes of action gives less chance of resistance, broader spectrum of control. The REI is NA and the PHI is NA due to use as soil/seed treatment.

- **Pyrethroid**

- Broader spectrum of control than other modes of action.
- Tefluthrin (Force 3G) @ 4 ounces per 1,000 ft. of row. Level of control is good to excellent. Costs a little more but safer for applicators to use than OPs. The REI is and the PHI is NA due to use as soil/seed treatment.
- Bifenthrin (Capture 2E) 0.30 fl oz per 1,000 ft of row. Level of control is fair. The REI is 24hrs and the PHI is 1d.

- **Carbamate**

- Carbofuran (Furadan 4F) @ 2 pints per acre - broadcast post- (at cultivation). Level of control is not known as it is not much used. It is a rescue option but little used otherwise. The REI is 48hrs and the PHI is NA due to use as soil/seed treatment.

- Other pest management aids:

- Change in tillage or sanitation; not effective for this pest. Monitoring systems - whole plant-beetle counts in continuous corn, scout soybean fields to base treatment decisions in following season. Crop rotation is biggest control option.

Chemical treatments for adult beetles:

- In the eastern Corn Belt, in areas of continuous corn; growers are encouraged to rotate crops.
- In the western Corn Belt treatment for adult beetles primarily occurs to prevent economic egg laying.
- In sweet corn adults often are killed as a result of control measures used for aphids or other insects.

- **Organophosphate**

- Many OP insecticides have offensive odors.
- Chlorpyrifos (Lorsban 4E) @ 1 to 2 pints per acre. Level of control is fair. Use is minor.

The REI is 24hrs and the PHI is 35d.

- Methyl Parathion (PennCap-M) @ 1 to 2 pints per acre. Level of control is fair to good. Minor use. The REI is 48hrs and the PHI is 3d.

• Carbamates

- Carbaryl (Sevin XLR) @ 2 to 4 pints per acre, Carbaryl (Sevin 80WSP) @ 1.25 to 2.5 pounds per acre.
- Level of control is fair to good. The REI is 12hrs and the PHI is 2d. Used by smaller fresh market growers due to broad spectrum.

• Pyrethroids

- Permethrin (Ambush 2EC) @ 6.4 to 12.8 ounces per acre. Permethrin (Pounce 3.2EC) @ 4 to 8 ounces per acre. Level of control is good. The REI is 12hrs and the PHI is 1d.
- Esfenvalerate (Asana XL) 0.66 EC @ 5.8 to 9.6 ounces per acre. Level of control is not known as it is not used, (assume it is not very effective). The REI is 12hrs and the PHI is 1d.
- Bifenthrin (Capture). Control is excellent. Used most along with Warrior and Mustang, spectrum picks up European corn borer and corn ear worm. The REI is 24hrs and the PHI is 1d.
- Lambda-cyhalothrin (Warrior 1E) @ 1.92 to 3.2 fluid ounces per acre. Level of control is excellent. Used most along with Warrior and Mustang, spectrum picks up European corn borer and corn ear worm. The REI is 24hrs and the PHI is 1d.
- Zeta-cypermethrin (Mustang). Level of control is good. Used most along with Warrior and Mustang, spectrum picks up European corn borer and corn ear worm. The REI is 12hrs and the PHI 3d.
- Cyfluthrin (Baythroid). Level of control is fair to good. The REI is 12hrs and the PHI is NA due to use as soil/seed treatment.

- **Other pest management aids:** No other practical aids exist.

Corn Earworm: [*Helicoverpa zea*] a.k.a. cotton bollworm, a.k.a. tomato fruitworm.

Biology and Life Cycle

Adults females oviposit on foliage, either on leaves early in the season or on fresh silks later in the season. Eggs typically hatch 5-7 days after being deposited. Corn earworms are migratory in nature and infestations are borne upon winds from southern US. Larvae cause damage to the corn by feeding deep inside the whorls, causing holes that measure 1-2 inches across, or by feeding on kernel tissue of ears. An estimated 50% of fields are infested annually by 1-3 or more larvae/plant (as high as 90% some

years). Quality (larvae contamination) issue.

Distribution and Importance:

Larvae are responsible for considerable ear damage. One larva can render an ear unmarketable.

Proper timing of insecticide application is critical as there are no control options once larvae enter the ear and are protected by the husk. Treatments are most effective during the early silk stage and prior to larvae entering the ear. Does not overwinter in this area, migrates from South and flies back in the fall

Wind patterns used for monitoring. Small overwintering population (south of I-80).

Chemical treatments:

• Organophosphates

- Chlorpyrifos (Lorsban 4E) @ 1Qt/acre. Level of control is poor, not used much, PHI too long. The REI is 24hrs and the PHI is 35d.
- Methyl Parathion (PennCap-M) @ 1 to 2 pints per acre. Level of control is poor, not much used, not efficacious. The REI is 48hrs and the PHI is 3d.

• Biologicals

- Bacillus thuringiensis (several trade names) See individual labels for rates. Level of control is poor, not acceptable. Used by organic growers because no other tools available - used numerous times. The REI is 4hrs and the PHI is 0d.

• Reduced-Risk

- Spinosad (Tracer). Level of control is fair on larvae only, doesn't control adults. Very expensive. The REI is 4hrs and the PHI is 3d.

• Carbamates

- Carbofuran (Furadan 4F) @ 0.25 to 0.5 pints per acre. Level of control is poor, very little use. Expensive. Dangerous to birds. The REI is 48hrs and the PHI is 7d.
- Methomyl (Lannate LV). Level of control is fair. The REI is 48hrs and the PHI is 0-3d.

• Pyrethroids

- Permethrin (Ambush 2EC) @ 6.4 to 12.8 ounces per acre. Permethrin (Pounce 3.2EC) @

- 4 to 8 ounces per acre. Level of control is fair to good. The REI is 12hrs and the PHI is 1d.
- Esfenvalerate (Asana XL) 0.66 EC @ 5.8 to 9.6 ounces per acre. Level of control is poor to fair, not used. The REI is 12hrs and the PHI is 1d.
- Lambda-cyhalothrin (Warrior) @ 2.56 to 3.84 fluid ounces per acre. Level of control is excellent. The REI is 24hrs and the PHI is 1d. Max rate is lower for hand harvested fresh market growers.
- Bifenthrin (Capture 2EC) 2.1-6.4 fl oz per acre, actual use rate is around 2.5 fl oz/A. Level of control is excellent in larvae and adult control. The REI is 24hrs and the PHI is 1d. Max rate is lower for hand harvested fresh market growers.
- Zeta-cypermethrin (Mustang). Level of control is good. Used most along with Warrior and Mustang, spectrum picks up European corn borer and CRW. The REI is 12hrs and the PHI is 3d.
- Cyfluthrin (Baythroid). Level of control is fair to good. The REI is 12hrs and the PHI is 2d.

• **Other pest management aids:**

- Process out damaged kernels - removal in processing by color sorters, and huskers spin off earworms for **processed** sweet corn only.

European corn borer [*Ostrinia nubilalis* (Hubner)]

Biology and Life Cycle:

Corn borers overwinter as larvae in corn stalks and pupate in the spring. Moths emerge from these pupae in May and June, the adults mate and females place eggs on the underside of corn leaves and on other suitable plant species. A second generation occurs in late July-August. In the northern Corn Belt only one generation may occur (univoltine populations). The moths prefer the tallest corn for oviposition, and when larvae hatch, they feed on leaf tissue. These larvae mature and pupate, with a second emergence of moths, usually occurring in late July and August. Second-generation European corn borer moths prefer late maturing corn for oviposition. The newly hatched second generation larvae feed lightly on leaves, but soon bore into leaf midribs, stalks and ear shanks. Ear drop is a problem and stalk tunneling can predispose plant to stalk rots. Economic thresholds for second generation corn borer are difficult to determine because of the long time period of egg laying and the relatively short persistence of foliar insecticides.

Pest Distribution and Importance:

An estimated 90% of fields are infested annually by 1-3 or more larvae/plant. Quality issue - larvae contamination issue. Late-planted corn will typically have greater infestations of corn borer and may be treated with more insecticide. Problem every year, everywhere. May be up to three generations or

univoltine.

Chemical treatments:

- **Organophosphates.** Most OPs have offensive odor
 - Chlorpyrifos (Lorsban 15G) @ 5 to 6.5 pounds per acre. Level of control is unknown as very little used. Worker safety is always a concern. The REI is 24hrs and the PHI is 35d.
 - Chlorpyrifos (Lorsban 4E) @ 1Qt/acre. Level of control is unknown as little is used. Expensive. Worker safety is always a concern. The REI is 24hrs and the PHI is 35d. The PHI is too long.
 - Methyl Parathion (Penncap-M) @ 1 to 2 pints per acre. Level of control is unknown as very little used. Worker safety is a concern. Not used as much in food industry due to label loss on other crops (pea and bean). Not effective on corn ear worm so not used for European corn borer- controlling both pests at same time. Kills bees. The REI is 48hrs and the PHI is 3d.

- **Biologicals**
 - Bacillus thuringiensis (several trade names) See individual labels for rates. Level of control is poor, not acceptable for most growers. The REI is 4hrs and the PHI is 0d. Some formulations are used by organic growers.

- **Reduced-Risk**
 - Spinosad (Tracer). Level of control is good on larvae. Expensive. The REI is 4hrs and the PHI is 3d.

- **Carbamates**
 - Carbofuran (Furadan 4F) @ 0.25 to 0.5 pints per acre. Level of control is fair to good. Very minor use due to worker safety and cost. Not rain fast. Other products work better. The REI is 48hrs and the PHI is 7d.

- **Pyrethroids**
 - Essential pesticide for control of European corn borer.
 - Permethrin (Ambush 2EC) @ 6.4 to 12.8 ounces per acre. Permethrin (Pounce 1.5G) @ 6.7 to 13.3 ounces per acre - some use. Permethrin (Pounce 3.2EC) @ 4 to 8 ounces per acre. Level of control is excellent. The REI is 12hrs and the PHI is 1d.
 - Esfenvalerate (Asana XL) 0.66 EC @ 5.8 to 9.6 ounces per acre. Level of control is poor. The REI is 12hrs and the PHI is 1d.

- Lambda-cyhalothrin (Warrior) @ 2.56 to 3.84 fluid ounces per acre. Level of control is excellent. The REI is 24hrs and the PHI is 1d.
- Bifenthrin (Capture 2EC) 2.1-6.4 fl oz per acre. Level of control is excellent. The REI is 24hrs and the PHI is 1d.
- Zeta-cypermethrin (Mustang). Level of control is good. Used most along with Warrior and Mustang, spectrum picks up European corn borer and CRW. The REI is 12hrs and the PHI 3d.
- Cyfluthrin (Baythroid). Level of control is fair to good. The REI is 12hrs and the PHI 2d.

• **Other pest management aids:**

- Black Light traps for monitoring.

Southwestern Corn Borer (*Diatraea grandiosella*)

Biology and Life Cycle:

Its life history and seasonal occurrence are similar to European corn borer. The second generation egg laying usually coincides with silking stage corn. Eggs are laid on both the upper and lower leaf surfaces. Heavy second generation infestations can develop even in areas where first generation activity was light. In addition to the types of damage caused by European corn borer, second generation Southwestern corn borer larvae increases harvest losses through plant lodging caused by girdling of the stalk 1 to 2 inches above the soil. While the biology of Southwestern corn borer is similar to that of European corn borer, peak moth flights occur after those of European corn borer, causing extended periods of corn borer larval activity. Weather-related planting delays can cause serious exposure to harvest losses by late-season Southwestern corn borer.

Pest Distribution and Importance:

Southwestern corn borer usually causes only light damage to early planted corn. In late corn plantings, first generation larvae can tunnel deep enough to kill the growing point and cause "dead heart"

Southwestern corn borer is not controlled by DIMBOA based plant resistance which protects small plants from European corn borer feeding. Treatment for second generation Southwestern corn borer is generally applied when 20 to 25% of the plants are infested with eggs. Often a second application 7 to 10 days after the first is needed if significant egg laying occurs after the first application. In BT corn, the same hybrids that have good European corn borer resistance are also resistant to Southwestern corn borer. When considering chemical control of second generation Southwestern corn borer, consider presence of spider mites in making product selection. In the eastern and southern portion of the Corn Belt; parts of Illinois, Indiana, Kansas, Kentucky, and Missouri, there is a complex of European corn borer and southwestern corn borer (Southwestern corn borer) attacking field corn. In these areas,

economic losses attributed to Southwestern corn borer is more frequent.

Chemical Controls

• Carbamates

- Carbofuran (Furadan 4F). Level of control is fair. The REI is 48hrs and the PHI is 7d.

• Pyrethroids

- Permethrin (Ambush 2E). (Pounce 3.2E). Level of control is good. The REI is 12hrs and the PHI is 1d.
- Esfenvalerate (Asana XL). Level of control is good. The REI is 12hrs and the PHI is 1d.
- Bifenthrin (Capture 2EC). Level of Control is good. The REI is 24hrs and the PHI is 1d

• Biologicals

- Bacillus thuringiensis (several trade names) See individual labels for rates. Level of control is fair. The REI is 4hrs and the PHI is 0d.
- Spinosad (Tracer). Level of control is good. The REI is 4hrs and the PHI is 3d.

• Other pest management aids:

- Early planting tends to enable a plant to tolerate damage but does not result in reduced infestation levels. Avoid late-planted corn; extremely late planted corn may be heavily infested with Southwestern corn borer, and yield losses due to tunneling may be extensive. Where soil erosion is not a concern, deep, clean plowing of corn stubble to a depth of 5 or more inches will bury larvae and pupae and prevent a high percentage of moth emergence the next spring. Overwinter survival of Southwestern corn borer is highest where corn stubble is left undisturbed. No-till producers need to be aware of the increased risk. Fall tillage to break up root stubble and expose borers to natural enemies and winter environment can decrease borer survival.

Black cutworm [*Agrotis ipsilon* Hufnagel]

Other cutworm species include: bristly, bronzed, claybacked, dingy, glassy, redbacked, sandhill, spotted, and variegated cutworms.

Biology and Life Cycle:

A number of cutworm species cause stand losses to young corn in the first month of growth. Black

cutworms do not overwinter in the north central states. Southerly winds carry moths north from overwintering areas along the Gulf of Mexico, and mated females lay their eggs in fields. The moths prefer weedy areas and plant residue to lay eggs. Once eggs hatch, larvae will feed on available vegetation. Fields subject to cutworm infestation often have preplant infestations of weeds or heavy surface debris. Other cutworm species do overwinter in the Midwest, survival varies with winter weather.

Pest Distribution and Importance:

Young cutworm larvae (1st-3rd instars) are very small and feed primarily on corn leaves. This injury is not considered economic. Larger larvae (4th and later instars) cut the plants off below, at, or just above the soil surface. If the plant is cut below the growing point the plant will not survive. Large numbers of black cutworms can drastically reduce the plant stand in given fields. In northern regions, tillage or burn down herbicides applied at least two weeks before planting greatly reduces damage by this pest. Sporadic pest with catastrophic results when it occurs, occurs more frequently in the southern portion of the region, and should be considered a pest of significant importance. Scouting is recommended and thresholds have been developed. Post-emergence rescue treatments are justified when 3% or more of plants are cut and larvae are still present. After the V6 stage corn is tolerant. Considered a minor pest overall.

Chemical treatments:

• Organophosphate

- Not much used due to poor efficacy.
- Chlorpyrifos (Lorsban 15G) @ 5 to 6.5 pounds per acre. Chlorpyrifos (Lorsban 4E) @ 1 to 2 pts per acre. Level of control is poor. The REI is 24hrs and the PHI is 35d.
- Methyl-Parathion (PennCap-M). Level of control is poor. The REI is 48hrs and the PHI is 3d.
- Chlorethoxyphos (Fortress 5G) @ 3.25 ounces per 1,000 ft of row in 30 inch -row spacings. Level of control is poor. The REI is 48-72hrs and the PHI is NA.

• Pyrethroids

- Insecticides of choice due to broad spectrum
- Permethrin (Ambush 2EC) @ 6.4 to 12.8 ounces per acre. Permethrin (Pounce 1.5G) @ 8 ounces per 1000 feet of row. Permethrin (Pounce 3.2EC) @ 4 to 8 ounces per acre. Level of control is good. The REI is 12hrs and the PHI is 1d.
- Esfenvalerate (Asana XL) 0.66 EC @ 5.8 to 9.6 ounces per acre. Level of control is good. The REI is 12hrs and the PHI is 1d.
- Lambda-cyhalothrin (Warrior) @ 1.92 to 3.2 fluid ounces. Level of control is good. The REI is 24hrs and the PHI is 1d.
- Bifenthrin (Capture). Control is good. The REI is 24hrs and the PHI is 1d.

- Tefluthrin (Force ST). Level of control is good. The REI is 0hrs and the PHI is NA due to use as soil/seed treatment.

- **Biological**

- *Bacillus thuringiensis* (many). Level of control is poor. The REI is 4hrs and the PHI is 0d.

- **Other pest management aids:**

- Tillage applied at least two weeks before planting greatly reduces damage by black cutworms.
- Improved Bt hybrids, if accepted by consumers, may provide good control.

Stalk Borer [*Papaipema nebris*]

Biology and Life Cycle:

Stalk borers are a native insect that damages corn by tunneling into plants and typically destroying the growing points. Damage is typically confined to field areas that are adjacent to borders of perennial grasses and broadleaf weeds, including road ditches, terrace backslopes, and grassed waterways. Perennial grasses like quackgrass and wirestem muhly and large broadleaf weeds, especially hemp (*Cannabis sativa*) and giant ragweed (*Ambrosia trifida*) are favored oviposition sites in the fall, and if these weeds are disseminated throughout the field, general damage can occur. Typically, stalk borer damage is limited to border rows, and treatments can be targeted to those border areas.

Pest Distribution and Importance:

This pest has a moderate level of importance; but local outbreaks can have a significant impact on yields. Control weeds and there won't be a significant problem. Minor pest and rarely treated.

Chemical treatments:

- **Organophosphate**

- Chlorpyrifos (Lorsban 4E) @ 2 to 3 pints per acre. Level of control is good. The REI is 24hrs and the PHI is 35d.

- **Pyrethroid**

- Insecticide of choice, good efficacy, availability and cost.

- Permethrin (Ambush 2EC) @ 6.4 to 12.8 ounces per acre. Permethrin (Pounce 1.5G) @ 6.7 to 13.3 ounces per acre. Permethrin (Pounce 3.2EC) @ 4 to 8 ounces per acre. Level of control is good. The REI is 12hrs and the PHI is 1d.
- Bifenthrin (Capture). Control is good. The REI is 24hrs and the PHI is 1d.
- Esfenvalerate (Asana XL) 0.66 EC @ 5.8 to 9.6 ounces per acre. Level of control is good. The REI is 12hrs and the PHI is 1d.
- Lambda-cyhalothrin (Warrior) @ 2.56 to 3.84 fluid ounces per acre. Level of control is good. The REI is 24hrs and the PHI is 1d.

• **Other pest management aids:**

- Clean tillage in the spring will destroy most overwintering eggs on weed residues in the field. Burn field edges and grassy borders in the spring reduces overwintering eggs. Adjusting planting dates has little or no effect on this pest.

Corn Leaf Aphids [*Rhopalosiphum maidis*]

Biology and Life Cycle:

Corn leaf aphids are colonial sucking insects that can rapidly increase population numbers to cover the emerging tassels and youngest leaves of stage R1 corn plants. This pest does not overwinter in most of the Corn Belt. Winged corn leaf aphids are transported to the Midwest by prevailing winds from southern regions. Although corn leaf aphid populations approaching 400 individuals per plant are necessary to warrant treatment, such populations do occasionally occur under favorable (dry) weather conditions. The primary damage from large populations is physiological, but secretion of honeydew can cause tassels to gum up and can reduce the effective dissemination of pollen. Scouting is most critical under drought conditions, and seed corn producers must pay special attention to protect pollen availability from inbred lines.

Pest Distribution and Importance:

Except under very dry conditions, this pest is of minor importance to corn production in most areas. High densities of actively feeding aphids will cause plant wilting and curling and ultimately necrosis of the upper leaves of the corn plant. Aphids excrete honeydew, which coats leaves and reproductive structures and may interfere with pollination. Honeydew also enhances other stalk rots and sooty mold. This can be a particular problem for fresh market sweet corn quality, detracting from the appearance of the silks and husks. Storage and transit may also be a factor in the presence of mold, especially when corn is improperly handled (without refrigeration in display or storage) by retailers.

Certain hybrids of corn favor aphid survival and they may have up to 9 generations/year. Where heavy Johnsongrass infestations are controlled, the aphid populations may move to nearby corn. Aphids also

carry the Maize Dwarf Mosaic (MDMV) virus.

Chemical treatments:

- Chlorpyrifos (Lorsban 4E) @ 1 to 2 Pints per Acre. Level of control is good. The REI is 24hrs and the PHI is 35d.
- Methyl Parathion (PennCap-M) @ 2 to 3 Pints per Acre. Level of control is good. The REI is 48hrs and the PHI is 3d.
- **Pyrethroids**
 - Bifenthrin (Capture). Control is excellent, product of choice. The REI is 24hrs and the PHI is 1d.
 - Lambda-cyhalothrin (Warrior) @ 2.56 to 3.84 fluid ounces per acre.
 - Level of control is good but weaker than Capture. The REI is 24hrs and the PHI is 1d.
 - Mustang. Doesn't control as well as other pyrethroids. The REI is 12hrs and the PHI is 3d.
 - Cruiser Control unknown.
- **Other pest management aids:** None listed.

Corn Flea Beetles [*Chaetocnema pulicaria* Melsheimer]

Biology and Life Cycle:

Flea beetles have enlarged hind legs which allow them to jump when disturbed. Corn flea beetles feed on corn leaf surfaces where they abrade the surface tissue and cause minor loss of leaf photosynthetic material. Two generations of flea beetles appear to be important to sweet corn; the overwintering generation that emerges with earliest plantings as soon as spring temperatures begin to warm, and a second generation that appears to peak about mid-June to early July. Numbers of flea beetles and incidence of Stewart's wilt decreases between early peak (associated with overwintering generation of beetles) and a second peak (associated with the second generation of flea beetles). Size of flea beetle populations late in the season are important in determining the size of the population that enters overwintering and subsequently, may vector *E. stewartii*, the following spring.

Pest Distribution and Importance:

Flea beetles play a major role in the transmission of Stewart's wilt, a bacterial disease of corn. The incidence of Stewart's wilt is generally tied to winter conditions that favor winter survival of corn flea beetles. The average air temperatures (in degrees F) for December, January and February are averaged and if the average is greater than 32, Stewart's wilt is of special concern. If the 3-month average is below

32, the risk is relatively small due to dead beetles. The feeding damage they cause to sweet corn leaves disrupts physiological processes. Damage is most severe when corn is young, <6 inches tall, and when growing conditions stress developing seedlings. Scout and apply rescue treatments should corn flea beetle numbers reach the economic threshold. Distribution is moving northward, more of a problem now than previously, especially in warm winters. 4 of last 10 winters are among the warmest winters in the last 100 years. Threshold is 1 in 100 plants in corn less than 6 inches tall, hybrid dependent.

Chemical treatments:

• Organophosphates

- Most have low efficacy and very little used.
- Chlorpyrifos (Lorsban 4E) @ 2 to 3 Pints per acre. Level of control is not indicated. The REI is 24hrs and the PHI is 35d.
- Methyl-parathion (PennCap-M) @ 2 to 3 Pints per acre. Level of control is not indicated. The REI is 48hrs and the PHI is 3d.
- Terbufos (Counter 15G) @ 8 ounces per 1,000 ft. of row. Terbufos (Counter CR) @ 6 ounces per 1,000 ft. of row. Level of control is not indicated. The REI is 48-72hrs and the PHI is NA due to use at planting.
- Phorate (Thimet 20G) @ 6 ounces per 1,000 Ft. of Row. Level of control is not known due to limited use. The REI is 48-72hrs and the PHI is NA due to use as soil/seed treatment.

• Carbamates - low efficacy

- Carbofuran (Furadan 4F) @ 2.5 Fl Ounces per 1,000 Ft of Row. Level of control is not indicated. The REI is 48hrs and the PHI is 7d.
- Carbaryl (Sevin XLR) @ 1 to 2 Quarts per acre. Level of control is good. Not used by processed growers, used by some fresh market growers. Used by fresh market growers because it isn't an RUP and has broad spectrum. Good retention on plant surface (XLR formulation). The REI is 12hrs and the PHI is 2d.

• Pyrethroids

- Permethrin (Ambush 2EC) @ 6.4 to 12.8 Ounces per acre. (Pounce 3.2EC) @ 4 to 8 ounces per acre. Level of control is good to excellent. The REI is 12hrs and the PHI is 1d.
- Esfenvalerate (Asana XL) 0.66 Ec @ 5.8 to 9.6 fl ounces per acre. Level of control is good, little use.
- Narrower spectrum. The REI is 12hrs and the PHI is 1d.
- Lambda-cyhalothrin (Warrior) @ 2.56 to 3.84 fl Ounces per Acre. Level of control is good to excellent. The REI is 24hrs and the PHI is 1d.
- Bifenthrin (Capture 2EC) 1.6 - 6.4 fl ounces per acre. Level of control is excellent. The

REI is 24hrs and the PHI is 1d.

- Zeta-cyfluthrin (Mustang). The REI is 12hrs and the PHI is 3d. Level of control is good.

- **Neonicotinoids.**

- For highly susceptible hybrids the following seed treatments are the preferred method of control in a high risk area.
- Imidacloprid (Gaucho). Level of control is excellent. The REI is 12hrs and the PHI is 7d.
- Thiamethoxam (Cruiser). Level of control is excellent. Works better in drier soils than Gaucho. Some research shows that Cruiser may increase plant vigor and plants mature earlier.

- **Other pest management aids:**

- Hybrids vary in tolerance to Stewart's wilt disease.

Sod Webworm [*Crambus* sp]

Biology and Life Cycle:

One generation per year occurs in the Midwest. Webworms that attack corn overwinter as partly grown caterpillars which developed in sod or other grasses the previous summer and fall. Larvae feed on leaves and may also cut the stalk like cutworms. Larvae are active as soon as corn emerges. Threshold levels for control are similar to corn cutworms.

Pest Distribution and Importance:

This insect is an occasional pest of corn and treatments are rarely required. This is a minor pest to corn production, usually in fields of corn planted into grass sod.

Chemical treatments:

- **Organophosphates:**

- Chlorpyrifos (Lorsban). Control is good. The REI is 24hrs and the PHI is 35d.

- **Pyrethroids**

- Permethrin(Pounce 1.5G) @ 6.7 to 13.3 ounces per acre. Permethrin (Pounce 3.2EC) @ 4 to 8 ounces per acre. Level of control is good. The REI is 12hrs and the PHI is 1d.

- Lambda-cyhalothrin (Warrior) @ 2.56 to 3.84 fluid ounces per acre. Level of control is good. The REI is 24hrs and the PHI is 1d
- Bifenthrin (Capture). Control is good. The REI is 24hrs and the PHI is 1d.

- **Other pest management aids:**

- Tillage of grass sod the year before corn production reduces populations since moths do not lay eggs in bare soil.

Hop Vine Borer (*Hydraecia immanis*)

Biology and Life Cycle:

Hop vine borers are soil dwelling and bore into the base of young corn plants where they destroy the growing points. Localized infestations can be intense and are often associated with weedy fields

Pest Distribution and Importance:

Very targeted regionally - very similar life cycle to stalk borer - more of a pest in the northern latitudes. Considered a minor corn production pest. Timing of controls must be exact.

Chemical treatments:

- **Pyrethroids**

- Permethrin (Pounce 3.2EC) @ 4 to 8 ounces per acre. Level of control is good. The REI is 12hrs and the PHI is 1d.

- **Other pest management aids:** None listed.

Fall Armyworm *Spodoptera frugiperda* True Armyworm [*Pseudaletia unipuncta* Haworth]

Biology and Life Cycle:

Fall armyworm overwinter and move northward annually from southern states because they cannot overwinter in locations where the ground freezes. Larvae range in color from light tan to black. They have a distinct inverted "Y" on the front of their head capsule. Fall Armyworm reach lengths of 1-1½ inches. Adult moths arrive from the gulf-coast states on strong southerly winds, similar to black cutworm. True armyworms overwinter in the north and favor grass as an oviposition site. Often, the

damage to young corn happens suddenly when the grass supply is consumed or when it is killed with a herbicide treatment. No-till fields must be observed closely, and treatments should be based on the presence of small army worm larvae feeding on the grass and the level of damage to corn.

Pest Distribution and Importance:

Very sporadic, but when it appears, it can be a significant pest - capable of destroying entire fields. True Armyworms often move from wheat fields to corn fields as the season progresses. Armyworm damage is characterized by ragged feeding and large amounts of frass (fecal pellets) on plants. The most severe damage occurs in sweet corn fields that are no-tilled into grass or alfalfa sod. Scouting and spraying of field perimeter is an effective method of control - no-till corn field near rye or other grassy field. This pest is considered of low to moderate importance to sweet corn production. Minor pest, regional problem on year to year basis, grassy weeds and cover crops - control grassy water ways.

Fall armyworm

Fall armyworm is harder to kill than true armyworm, a problem later in the season in the north but can be a problem early on for late planted sweet corn in Illinois. Fall armyworm is an aggressive feeder.

Application timing critical, kill before silking process. Products of choice are pyrethroids, Pounce, Capture and Mustang. OP usually have poor efficacy.

Chemical treatments:

- **Organophosphate**

- Not used for fall armyworm due to poor efficacy.
- Chlorpyrifos (Lorsban 4E) @ 1 to 2 pts/acre. Level of control is poor. The REI is 24hrs and the PHI is 35d.
- Methyl Parathion (Penncap-M) @ 2 to 3 pts/acre. Level of control is poor. The REI is 48hrs and the PHI is 3d.

- **Carbamates**

- Carbaryl (Sevin). Control is good especially in fresh market. The REI is 12hrs and the PHI is 2d.
- Methomyl (Lannate LV) @ 0.75 to 1.5 pints per acre. Level of control is good. The REI is 48hrs and the PHI is 0-3d.

- **Biological**

- *Bacillus thuringiensis* (several trade names) Level of control is poor, it has some activity,

used by organic growers. The REI is 4hrs and the PHI is 0d.

- Spinosad (Tracer). Control is good. The REI is 4hrs and the PHI is 3d.

- **Pyrethroids**

- Products of choice.
- Permethrin (Ambush 2EC) @ 6.4 to 12.8 ounces per acre. (Pounce 1.5G) @ 6.7 to 13.3 ounces per acre. (Pounce 3.2EC) @ 4 to 8 ounces per acre - prior to brown silk stage. Level of control is good. The REI is 12hrs and the PHI is 1d.
- Esfenvalerate (Asana XL) 0.66 EC @ 5.8 to 9.6 ounces per acre. Level of control is good. The REI is 12hrs and the PHI is 1d.
- Bifenthrin (Capture). Control is good. The REI is 24hrs and the PHI is 1d.

- **Other pest management aids:** None listed.

Twospotted Spider Mite [*Tetranychus urticae* Koch] and **Banks Grass Mite** [*Oligonychus pratensis*]

Biology and Life Cycle:

Twospotted spider mite has very broad host range, reproducing on grass and broadleaf crops and weeds. Banks grass mite is restricted to grassy crops and weeds. Both species have high reproductive rates, and short life cycle and can produce multiple generations in a growing season. Spider mites feed on the underside of lower leaves, moving up the plant as populations develop. They feed by sucking juices from leaf cells, leaving yellow dots where they feed. When abundant they can kill leaves. Infestations at the level of the ear often cause economic yield losses. Populations may increase after insecticide applications made for other insects, because broad spectrum insecticides kill predatory insects and mites which help suppress mite population growth. Populations may rebound quickly after miticide application, because except for propargite, miticides are not effective against eggs, and miticides also kill mite natural enemies (predatory mites and insects).

Pest Distribution and Importance:

Spider mites are controlled during most years by a naturally occurring disease and arthropod natural enemies (predator spider mites and insects). However, when there are prolonged periods of low humidity, the fungus is suppressed, allowing the spider mite population to proliferate. If adverse weather conditions continue, re-treatment may be needed. In the eastern Corn Belt region it is not considered a pest of importance on corn. More commonly they are a pest in the western Corn Belt.

Two spotted spider mites are less susceptible to most pesticides than Banks grass mite. Banks grass mite may colonize corn early in the season as small grains or pasture grasses mature. Two spotted spider mites normally colonize corn later in the season (late whorl-reproductive stages)

Chemical controls:

- Spot treatments are recommended if only part of the field is infested; re-infestation and resurgence is possible after treatment due to egg hatch and destruction of beneficial insects and mites.
- **Organophosphate**
 - Dimethoate (Cygon 400) @ 1 pt. per acre. Level of control is good. The REI is 48hrs and the PHI is 14d.
- **Organosulfite**
 - Propargite (ComiteII) 2.5 qt per acre. Level of control is good. The REI is 7d and the PHI is 30d.
- **Pyrethroids**
 - Bifenthrin (Capture) 2EC 2.1 to 6.4 fl oz per acre. Level of control is good. The REI is 24hrs and the PHI is 1d.
- **Other pest management aids:**
 - Bt corn hybrids may decrease mite outbreaks by decreasing use of broad spectrum insecticide for corn borers. (Bt sweet corn has not been readily accepted by consumers).

Grasshoppers (predominantly 4 species: **differential** [*Melanoplus differentialis* Thomas], **twostriped** [*Melanoplus bivittatus* Say], **redlegged** [*Melanoplus femurrubrum* DeGeer], **migratory** [*M. sanguinipas*])

Biology and Life Cycle:

Grasshoppers are common mid- to late-summer pests of corn. These insects hatch in grassy field edges and other grassy areas where they will feed, and then gradually spread into production fields. The presence of grasshoppers in border areas is not necessarily a cause of alarm. Adult grasshoppers are better controlled with some of the pyrethroid and carbamate insecticides.

Pest Distribution and Importance:

Cultural practice of delayed mowing of ditch banks etc will assist in keeping the grasshoppers out of production fields. Grasshoppers are considered of low importance to corn production. Greatest yield losses are caused by the loss of leaf area during tassel and silking stages. A 20% loss of leaf area during this time will result in about 7% loss in yield. However, scouting is pertinent, because it is important to only treat when the population reaches economic thresholds.

Chemical treatments:

• Organophosphate

- Chlorpyrifos (Lorsban 4E) @ 0.5 to 1 pt/acre. Level of control is good. The REI is 24hrs and the PHI is 35d.
- Methyl Parathion (PennCap-M) @ 2 to 3 pints per acre. Level of control is good. The REI is 48hrs and the PHI is 3d.
- Dimethoate (Cygon). Control is good. The REI is 48hrs and the PHI is 14d.

• Carbamates

- Carbaryl (Sevin). Control is good. The REI is 12hrs and the PHI is 2d.

• Pyrethroids

- Esfenvalerate (Asana XL 0.66 EC) @ 5.8 to 9.6 ounces per acre. Level of control is good. The REI is 12hrs and the PHI is 1d.
- Cyhalothrin (Warrior) 2.56-3.84 fl oz per acre. The REI is 24hrs and the PHI is 1d.
- Zeta-Cypermethrin (Mustang) 2.9-4.3 fl oz per acre. The REI is 12hrs and the PHI is 3d.
- Bifenthrin (Capture). Control is good. The REI is 24hrs and the PHI is 1d.

• Other pest management aids:

- Sanitation: Avoid trimming weeds and grass around field border during dry weather to discourage grasshoppers from moving into the corn field.

Western Bean Cutworm (*Loxagrotis albicosta*)

Biology and Life Cycle:

Western bean cutworm is a pest that can severely damage ears, resulting in potentially large yield and grain quality problems. One generation per year; larvae overwinter in soil. Populations survive

overwintering best in well drained soils. The adults oviposit on upper surfaces of corn leaves or on dry edible field bean leaves. Corn fields in late whorl stage are the most attractive to females for egg laying. New larvae are about ¼ inch in length and are dark brown. These larvae feed on pollen and then move to ears where they feed until dropping to the ground and form a subterranean overwintering chamber.

Pest Distribution and Importance:

Timing of treatments is critical, because once the larvae reach the ear tips they are then shielded from the insecticide. Fields treated with pyrethroid insecticides should be monitored closely for subsequent spider mite infestations. Typically a pest in Nebraska, Kansas, Colorado; recently has also been found in NW Iowa and southern MN.

Chemical Controls:

• Organophosphates:

- Chlorpyrifos (Lorsban 4E) @ 0.5 to 1 pt/acre. Level of control is good. The REI is 24hrs and the PHI is 35d.
- Methyl Parathion (Penncap-M) @ 2 to 3 pints per acre. Level of control is good. The REI is 48hrs and the PHI is 3d.

• Carbamates

- Carbaryl (Sevin XLR Plus) 2 qts per acre. Control is good. The REI is 12hrs and the PHI is 2d.

• Pyrethroids:

- Permethrin (Ambush 2EC) @ 6.4 to 12.8 ounces per acre. Permethrin (Pounce 3.2EC) @ 4 to 8 ounces per acre. Level of control is good. The REI is 12hrs and the PHI is 1d.
- Esfenvalerate (Asana XL) 0.66 EC @ 5.8 to 9.6 ounces per acre. Level of control is poor. Not used much, not very effective. The REI is 12hrs and the PHI is 1d.
- Bifenthrin (Capture). Control is excellent. Used most along with Warrior and Mustang, spectrum picks up European corn borer and corn ear worm. The REI is 24hrs and the PHI is 1d.
- Lambda-cyhalothrin (Warrior 1E) @ 1.92 to 3.2 fluid ounces per acre. Level of control is excellent. Used along with Mustang, spectrum picks up European corn borer and corn ear worm. The REI is 24hrs and the PHI is 1d.
- Zeta-cypermethrin (Mustang). Level of control is good. Used most along with Warrior, spectrum picks up European corn borer and corn ear worm. The REI is 12hrs and the PHI is 3d.

- **Other Pest Management Aids:**

- Bt foliar sprays not effective against western bean cutworms.

Japanese Beetle

Japanese beetles are about 5/8 inch long and overwinter as a larva or grub in the soil. The strong-flying adults typically emerge from the soil in July in great numbers and feed heavily upon available foliage. Soaking rains can also cause damage, as it urges successive invasions by the beetles. If effective insecticides are not used on affected areas beetles from afar will tend to make their way to the fresh sweet corn.

Chemical treatments:

- **Organophosphate**

- Chlorpyrifos (Lorsban 4E) @ 0.5 to 1 pt/acre. Level of control is good. The REI is 24hrs and the PHI is 35d.
- Methyl Parathion (Penncap-M) @ 2 to 3 pints per acre. Level of control is good. The REI is 48hrs and the PHI is 3d
- Dimethoate (Cygon). Control is good. The REI is 48hrs and the PHI is 14d.

- **Carbamates**

- Carbaryl (Sevin). Control is good. The REI is 12hrs and the PHI is 2d.

- **Pyrethroids**

- Esfenvalerate (Asana XL 0.66 EC) @ 5.8 to 9.6 ounces per acre. Level of control is good. The REI is 12hrs and the PHI is 1d.
- Cyhalothrin (Warrior) 2.56-3.84 fl oz per acre. Level of control is good. The REI is 24hrs and the PHI is 1d.
- Zeta-Cypermethrin (Mustang) 2.9-4.3 fl oz per acre. Level of control is good. The REI is 12hrs PHI 3d.
- Bifenthrin (Capture). Control is good. The REI is 12hrs and the PHI is 1d.

- **Other pest management aids:** None listed

Sap Beetles

The sap beetle overwinters as an adult in soil or debris. The adult beetle is approximately 1/8 inch long and black with white or yellow spots on the wing covers. Adults feed on ripening pollen, chew tassels, and damage kernel tissue allowing diseases to enter the plant. Sometimes used as a beneficial insect for European corn borer before July 4, feed in tunnels of European corn borer and kills European corn borer. After July 4 becomes a pest. Incidental to control of other pests. Exposed tip hybrids are more susceptible. Application window for sap beetle is 10 days to 0 days before harvest.

Chemical treatments:

- Products used to control corn ear worm and European corn borer also control sap beetle.
- **Organophosphate**
 - Chlorpyrifos (Lorsban 4E) @ 0.5 to 1 pt/acre. Level of control is not indicated. The REI is 24hrs and the PHI is 35d.
 - Methyl Parathion (PennCap-M) @ 2 to 3 pints per acre. Level of control is good. The REI is 48hrs and the PHI is 3d.
- **Carbamates**
 - Carbaryl (Sevin). Control is poor to fair. The REI is 12hrs and the PHI is 2d.
- **Pyrethroids**
 - Esfenvalerate (Asana XL 0.66 EC) @ 5.8 to 9.6 ounces per acre. Level of control is used very little. The REI is 12hrs and the PHI is 1d.
 - Cyhalothrin (Warrior) 2.56-3.84 fl oz per acre. Level of control is good, some used. The REI is 24hrs and the PHI is 1d.
 - Zeta-Cypermethrin (Mustang) 2.9-4.3 fl oz per acre. Just registered in 2002. Level of control is good. The REI is 12hrs and the PHI is 3d.
 - Bifenthrin (Capture) preferred method of control. Level of control is good. The REI is 24hrs and the PHI is 1d.
- **Other pest management aids:** None listed.

Insecticides:

Annual insecticide use, rates of application and number of applications is estimated in Table 6. A brief summary of labeled application rates and REI and PHI restrictions are found in Table 7. Also included in Table 7 is more detailed information about insecticides use for specific insects.

Insecticide use varies annually by region and by pest. Fresh market sweet corn produced on commercial farms, may use more insecticide than sweet corn for processed uses. Typically fresh market sweet corn will spray insecticide closer to the date of harvest to insure fewer insects contaminate the corn which is sold on the ear.

Table 6. Insecticide: area applied, rate, and number of applications for 2003

Insecticide	Area Applied (%)	Rate/ Application	# of applications
Chlorpyrifos	1	1.16	1
Permethrin	30	0.11	3
Tefluthrin	30	0.12	3
Terbufos	1	1.24	1
Cyfluthrin	30	0.006	3
Tebupirimphos	1	0.12	1
Imidacloprid	10	10oz/100# seed	1
Lambda cyhalothrin	50	.02	3
Bifenthrin	30	.02	3
Zeta-cypermethrin	50	.025	3

Table 7. Insecticide Rates, MOA, REI, PHI and Target Insects

Trade Name	Common Name	Rate/Acre Low..... High	Unit	REI Hrs	PHI Days	Primary Target
Ambush, Pounce	permethrin	0.1---0.2	lb	12	1	cutworms, flea beetles, european corn borer, corn earworm,
Asana	esfenvalerate	0.03---0.05	lb	12	1	cutworms, flea beetles, corn earworm
Aztec	cyfluthrin +tebupirimphos	see label		48	P	corn rootworm

Baythroid	cyfluthrin	0.0125--- 0.044	lb	12	2	cutworms, european corn borer, corn earworm, fall armyworm
Capture	bifenthrin	0.033--- 0.10	lb	18** 24***	1	flea beetles, european corn borer, corn earworm, fall armyworm
Counter G	terbufos	0---1	lb	48	P	corn rootworm
Diazinon	diazinon	1-2	pt	24	7	flea beetle, aphid, corn earworm, sap beetle, grasshopper, rootworm beetle
Force 1.5G and 3G	tefluthrin	3---5	oz/ 1000 ft	0	P	corn rootworm
Furadan	carbofuran	0---2.5	fl/oz	48	P / 7	flea beetles, European corn borer, corn earworm
Gaicho	imidacloprid	8---16	floz/100 #seed			flea beetles
Lannate	methomyl	0.23---0.45	lb	48	0-3	corn earworm, fall armyworm
Lorsban	chlorpyrifos	1---1.5	lb	24	35	cutworms, flea beetle,
Lorsban G	chlorpyrifos	0---1	lb	12	P	corn rootworms
Mustang 1.5EW	zeta-cypermethrin	2.4-4.3	oz	12	3	corn rootworm adults, corn earworm, corn borer

PennCap M	methyl parathion	1-2	pt	48	3	black cutworm, armyworm, flea beetle, aphid, corn earworm, European corn borer, rootworm beetles, sap beetles
Sevin	carbaryl	1---2	lb	12	2	sap and picnic beetles, corn earworm, european corn borer, japanese beetle, flea beetles
SpinTor	spinosad	0.023---0.094	lb	4	3	fall armyworm, corn earworm, european corn borer,
Thimet G	phorate	0---1	lb	48-72	P	corn rootworm
Warrior	lambda-cyhalothrin	0.02---0.03	lb	24	1	cutworms, flea beetles, european corn borer, corn earworm, fall armyworm

P=apply at or before planting or as early in season side-dress according to label

Fresh * Processed

Diseases

For sweet corn, the most frequently cited diseases and pathogens are: seedling diseases and blights (Pythium, Fusarium, and Penicillium), leaf blights (Northern Corn Leaf Blight, anthracnose leaf blight, and gray leaf spot) Stewart's wilt and blight, viruses (Maize dwarf mosaic) rust and smut. Fusarium species of fungi, in particular, increase when crop residues are present. These fungi commonly cause root rot and also invade corn stalks, causing stalk rots. Many leaf blights are spread through plant residue. Corn seeds are treated to avoid infection by spores in the soil and on the seed. Essentially all

corn seed is treated with a broad-spectrum protectant fungicide that adds very little additional cost to production. Some foliar spraying may be necessary.

Table 8. Estimates⁴ of Crop Loss and Acres Infested by Diseases

Common Name	Scientific Name	Avg. Acres Infested*	Avg. % Crop Loss**
Common Rust	<i>Puccinia sorghi</i>	10	10
Common Smut	<i>Ustilago maydis</i>	15	7
Maize Dwarf Mosaic Virus	MDMV	1	1
Northern Corn Leaf Blight	<i>Exserohilum turcicum</i>	0	0
Stewart's Wilt and Blight	<i>Erwinia stewartii</i>	1	1
Seedling blight	<i>Collectotricum graminicola</i>		
Gray leaf spot	<i>Cercospora zea-maydis</i>		
Barley Yellow Dwarf Mosaic	BYDM		

* Infested at economic level

** Loss averaged over last 3 to 5 years.

Seed Decay and Seedling Blight

Biology and Life Cycle:

These diseases are generally caused by soil-inhabiting fungi such as *Pythium*, *Fusarium*, *Diplodia*, *Rhizoctonia*, and *Penicillium*. These fungi also may be seedborne, except for *Pythium*. Seeds may be rotted before germination or the seed may germinate and the seedling infected and blighted (damping-off). This can occur as either pre-emergence damping-off or post-emergence damping-off.

Pest Distribution and Importance:

Damping-off is favored by cool, wet soils, so it is more common in low-lying or poorly drained areas or in fields planted too early in the spring. *Penicillium* 4-leaf die-back is favored by warm temperatures. *Pythium* seedling blight and seed rot is favored by wet soils and cool temperatures. Seed rot and

seedling blight due to *Fusarium* spp. Is favored by any environmental condition that hampers seedling growth and vigor (usually a combination of cold temperature and wet soils). Heavy residue on the soil surface can favor damping-off by suppressing soil temperature and drying. Other factors that delay germination and emergence such as herbicide damage, compaction, crusting, or planting too deep, can result in more seedling blight. Seed/seedling diseases are controlled by seed treatment only. Human exposure to chemical seed treatment materials, once the seed is in the ground, is minimal and would only occur when loading seed into planter and checking planter boxes or moving seed. Seed comes already treated in bag. Very little corn replanted due to seedling blight because of treated seed. Seed treatment lasts just long enough to get seed germinated. In the absence of seed treatments severe losses would be incurred in localized areas. Have to establish a good, uniform stand, seed rots detract from this.

Chemical Control

Need to be broad spectrum to control all potential problems - This is CRITICAL.

- **Phenylpyroles**

- Fludioxonil (Maxim) Level of control is good to excellent for *Penicillium*/*Fusarium*, fair for *Pythium*. Seed comes pre-treated. The REI is NA and the PHI is NA due to use as seed/soil treatment.

- **Phenylthalamides**

- Captan (Captan) Level of control is fair to good. The REI is NA and the PHI is NA due to use as seed/soil treatment.

- **Phenylamides**

- Metalaxyl (Apron) Level of control is excellent for *Pythium*, poor to none for others. The REI is NA and the PHI is NA due to use as seed/soil treatment.
- Mefenoxam (Apron XL). Level of control is excellent for *Pythium*, poor to none for others. The REI is NA and the PHI is NA due to use as seed/soil treatment.

- **Other pest management aids:**

- Damping-off is generally controlled by seed treatment with a fungicide on almost all seed corn. This is sufficient in most cases, but not under severe conditions. Plant corn when the soil temperature is above 50°F and soil moisture is not excessive. Seeds should not be planted too deep; about 1 1/2 to 2 inches is best, depending on soil conditions. Improved field drainage/ later plantings on warmer soils.

Root Rots

Biology and Life Cycle:

Root rots of corn are common, and can be caused by a number of fungal pathogens including *Pythium* spp., *Fusarium graminearum* and other *Fusarium* species. Root rots occur to some extent in every field.

Pest Distribution and Importance:

Wet soil conditions predispose plants to root rots because of oxygen deficiency, and the root rot fungi thrive under these conditions. Highly compacted or otherwise poorly drained soils are particularly prone to root rots. Many of the stalk rot pathogens enter through the roots and cause a root rot in advance of the stalk rot. Root rots are generally not economically significant and are considered of minor importance to corn production. But under wet conditions, root rots cause economic losses.

No products are sold to control root rots, therefore very little research has been done on them.

Root rots may be mis-diagnosed as another disease/injury. Common in early sweet corn

Chemical controls:

- The seed treatments used for seedling rots and seed decay have some limited effect on root rots. No products are specifically available and labeled to control root rots.
- **Other pest management aids:**
 - Under good growing conditions losses to root rots are negligible, and control measures are not necessary. Improved drainage reduces the risk of root rots when wet conditions occur. Soil drying can be enhanced through a reduction in surface residue or cultivation, but the value of these practices in reducing root rot has not been demonstrated.

Foliage and Aboveground Diseases

Eyespot *Aureobasidium zeae*

Biology and Life Cycle:

Eyespot is caused by the fungus *Aureobasidium zeae*, previously known as *Kabatiella zeae*. This fungus overwinters in corn residue and in wet conditions produces conidia that are spread by splashing water

and wind. The disease is much more common when corn follows corn. Eyespot may appear early in the season on lower leaves and again near the end of the season on upper leaves.

Pest Distribution and Importance:

Eyespot is more prevalent in the northern part of the Corn Belt. Early maturing hybrids seem to be more susceptible. Field corn is seldom treated with foliar fungicides for this disease.

Chemical Controls

- **Ethylenebisdithiocarbamates**

- Mancozeb, (Dithane, Mancozeb, etc) Level of control is good. The REI is 24hrs and the PHI is 7d.

- **Triazoles**

- Propiconazole, (Tilt) Level of control is good. The REI is 24hrs and the PHI is 14d.

- **Strobilurins**

- Azoxystrobin (Quadris). Level of control is good. The REI is 4hrs and the PHI is 7d

- **Substituted Benzenes**

- Chlorothalonil,(Bravo) Level of control is good. The REI is 48hrs and the PHI is 14d. Only for fresh market, not for processed sweet corn.

- **Other pest management aids:**

- Resistant hybrids are available. Crop rotation or reducing surface residue through tillage reduces inoculum. In reduced tillage systems, resistance and rotation are very important control measures.. Fungicides can be used to control leaf diseases in corn, but usually they are economical only in seed corn, popcorn, or sweet corn production. More than one application is necessary when conditions are favorable for disease.

Common smut *Ustilago zae*

Biology and Life Cycle:

Common smut is caused by the fungus *Ustilago zae*, previously known as *Ustilago maydis*, which overwinters in corn residue or soil. This fungus produces black teliospores that survive well in soil.

These teliospores germinate during the spring and summer, with each teliospore then producing four smaller spores, called sporidia. Infection of ears occurs exclusively from colonization of and infection through silks. Each kernel is infected separately via the silk (extended ovary wall) attached to that kernel. Pollination protects kernels from infection by *U. maydis* as a result of an abscission layer of dead cells that forms at the base of the silk. *U. maydis* is unable to grow across the abscission layer and silks become detached from kernels soon after this layer forms which also prevents infection.

Aggravated by crop injury from hail, cultivators, etc. Sporidia are spread by wind and water. All above ground plant parts are susceptible, especially the actively growing meristematic tissue. Sporidia can infect through unwounded cells, but wounds caused by insects, detasseling, cultivation, hail, or blowing soil are important infection sites as well.

Pest Distribution and Importance:

Disease is favored by excess nitrogen, excess manure or herbicide injury, and relatively dry, warm weather. Factors that cause the timing of pollen production and silk emergence to diverge (e.g. drought stress) increase the incidence of ear smut. This disease is of major importance when it occurs. Control can be assisted by avoiding mechanical injury and establishing well-balanced soil fertility. Number one disease problem for mechanically harvested fresh market corn. Yield, quality and case recovery - smut impacts all of these. (For every 5% of smut one case per ton is lost). Hybrid specific losses

Chemical controls:

- This disease does not receive chemical treatment.
- **Other pest management aids:**
 - Some hybrids are (marginally) less susceptible than others. Rotation and tillage will not affect the occurrence of smut, since the teliospores survive well in the soil. Avoiding mechanical damage through cultivation can reduce the risk of disease. Maintenance of balanced fertility and avoiding herbicide injury also will reduce the risk of disease. Avoid stress that affects timing of pollen production and silk emergence.

Northern Corn Leaf Blight

Biology and Life Cycle:

Northern leaf blight is caused by the fungus *Exserohilum turcicum*, previously called *Helminthosporium turcicum*. There are at least seven races of the fungus. The fungus overwinters as mycelium and spores in corn residue. Spores are dispersed by wind and splashing water.

Pest Distribution and Importance:

This has traditionally been the most consistently damaging leaf disease of field corn in the northern Corn Belt, but its severity has decreased due to improvements in resistance. This disease is important to susceptible sweet corn hybrids. It occurs throughout the eastern half of the United States, as far west as eastern Nebraska. Disease development is favored by extended periods of leaf wetness (rain or dew) and moderate temperatures (64-81°F). Fungicides may be economical if hybrids have moderate to susceptible reactions to Northern corn leaf blight. Cyclic problem based on weather pattern, crop rotation and hybrid. Can be devastating, losses vary by a factor of 5 annually. Disease has a latent period of 10 days.

Chemical Controls:

- Multiple modes of action are essential for managing resistance development. All currently registered products should remain registered for control of this pest.
- **Ethylenebisdithiocarbamates**
 - Mancozeb, (Dithane, Mancozeb, etc) Level of control is fair. The REI is 24hrs and the PHI is 7d.
- **Triazoles**
 - Propiconazole (Tilt) Level of control is fair to good. The REI is 24hrs and the PHI is 14d.
- **Strobilurins**
 - Azoxystrobin (Quadris). Level of control is excellent, product of choice currently. Potential for resistance. The REI is 4hrs and the PHI is 7d.
 - Stratego (propiconazole plus trifloxystrobin). Level of control is good to excellent. Expensive. Possibly effective strategy for resistance management.
- **Substituted Benzenes**
 - Chlorothalonil (Bravo) Level of control is fair. The REI is 48hrs and the PHI is 14d. Not used for processed sweet corn, used for fresh market.
- **Other pest management aids:**
 - Northern leaf blight can be controlled by two types of resistance, monogenic or polygenic. The monogenic Ht resistance does not confer resistance to all races of the fungus. Hybrids

with an Ht gene may become susceptible if new races appear in the area. Polygenic resistance confers resistance to all races, but the resistance is not as absolute as Ht resistance. The level of polygenic resistance varies among hybrids. Crop rotation or reducing surface residue through tillage reduces inoculum. In reduced tillage systems, resistance and rotation are very important control measures. Reducing surface residue may not be a practical solution where conservation tillage is a priority.. Fungicides can be used to control leaf diseases in corn, but usually they are economical only on moderately susceptible hybrids. More than one application is necessary when conditions are favorable for disease.

Northern Corn Leaf Spot *Bipolaris zeicola*

Biology and Life Cycle:

Northern corn leaf spot is caused by the fungus *Bipolaris zeicola*, previously known as *Cochiobolus carbonum*. There are five known races of this fungus with different virulence characteristics and symptoms. Race 0 is nearly avirulent to corn, and race 1 is virulent on only a few genotypes. Races 2 and 3 are the most common races in the Midwest. Race 2 is not specific for corn genotypes, while race 3 is only a problem on certain susceptible lines. A fifth race has been reported recently. *B. zeicola* overwinters as mycelium and spores in corn residue, and the spores are dispersed by wind and splashing water.

Pest Distribution and Importance:

This disease is favored by high humidity and moderate temperatures. This disease rarely occurs in modern hybrids and is not treated with fungicides.

Chemical controls:

- **Ethylenebisdithiocarbamates**

- Mancozeb, (Dithane, Mancozeb, etc) Level of control is good (not used). The REI is 24hrs and the PHI is 7d.

- **Triazoles**

- Propiconazole, (Tilt) Level of control is good (not used). The REI is 24hrs and the PHI is 14d.

- **Strobilurins**

- Azoxystrobin (Quadris). Level of control is good (not used). The REI is 4hrs and the PHI is 7d.

- **Substituted Benzenes**

- Chlorothalonil, (Bravo) Level of control is good (not used). The REI is 48hrs and the PHI is 14d. Not for processed sweet corn.

- **Other pest management aids:**

- Crop rotation or reducing surface residue through tillage reduces inoculum. In reduced tillage systems, resistance and rotation are very important control measures. Fungicides can be used to control leaf diseases in corn, but usually they are economical only in seed corn, popcorn, or sweet corn production. More than one application is necessary when conditions are favorable for disease.

Anthracnose Leaf Nlight *Colletotrichum graminicola*

Biology and Life Cycle:

Anthracnose leaf blight is caused by the fungus *Colletotrichum graminicola*. It overwinters as mycelium or sclerotia in corn residue or seed. Several weed species also are hosts and may act as inoculum sources. Spores are spread primarily by splashing water.

Pest Distribution and Importance:

Disease development is favored by wet weather with warm temperatures, especially at seedling stages. Anthracnose is much more common where corn follows corn. This disease occurred in outbreak proportions in 2000, but was not much of a problem in 2001. Problems are usually localized but can be severe. There is a noticeable trend for greater occurrence in recent years due to reduced tillage.

Chemical Controls:

- Multiple modes of action are essential for managing resistance development. All currently registered products should remain registered for control of this pest.
- **Ethylenebisdithiocarbamates**
 - Mancozeb, (Dithane, Mancozeb, etc) Level of control is fair to good. The REI is 24hrs and the PHI is 7d.

- **Triazoles**

- Propiconazole, (Tilt) Level of control is fair. The REI is 24hrs and the PHI is 14d.

- **Strobilurins**

- Azoxystrobin (Quadris). Level of control is not indicated. The REI is 4hrs and the PHI is 7d.

- **Substituted Benzenes**

- Chlorothalonil, (Bravo) Level of control is good. The REI is 48hrs and the PHI is 14d. Not for processed sweet corn.

- **Other pest management aids:**

- Avoid moderately susceptible and susceptible hybrids. Crop rotation or reducing surface residue through tillage reduces inoculum. In reduced tillage systems, resistance and rotation are very important control measures.

Gray Leaf Spot *Cercospora zea-maydis*

Biology and Life Cycle:

Gray leaf spot is caused by the fungus *Cercospora zea-maydis*. The fungus survives as mycelium in corn residue, and spores are dispersed by wind and splashing water.

Pest Distribution and Importance:

This disease is a problem in the eastern United States, and it has grown in importance in the western Corn Belt as far west as central Nebraska. Gray leaf spot is much more common in the southern half of the North Central Region. It is particularly severe when corn follows corn and in areas of irrigation. Sporulation and disease development are favored by warm, humid weather. This is a widespread and economically significant problem in corn production. Very few hybrids have tolerance. By the time symptoms are readily apparent it may be too late for control measures. Primarily a problem on late planted sweet corn. Problem in Illinois in seed corn production areas. Bigger problem in late corn, once symptoms are evident it is a problem, incubation period variable depending on growth stage

Chemical Controls:

- Multiple modes of action are essential for managing resistance development. All currently registered products should remain registered for control of this pest.
- **Ethylenebisdithiocarbamates**
 - Mancozeb, (Dithane, Mancozeb, etc) Level of control is good. The REI is 24hrs and the PHI is 7d.
- **Triazoles**
 - Propiconazole, (Tilt) Level of control is fair to good. Timing is critical. The REI is 24hrs and the PHI is 14d.
- **Strobilurins**
 - Azoxystrobin (Quadris). Level of control is good. The REI is 4hrs and the PHI is 7d.
- **Substituted Benzenes**
 - Chlorothalonil, (Bravo) Level of control is not indicated. The REI is 48hrs and the PHI is 14d. Not for processed sweet corn.
- **Other pest management aids:**
 - Some hybrids are more tolerant to gray leaf spot, but control is variable and may not be adequate. Crop rotation or reducing surface residue through tillage reduces inoculum. In reduced tillage systems, resistance and rotation are very important control measures.

Stewart's Disease *Erwinia stewartii*

Biology and Life Cycle:

This disease, also called Stewart's wilt or bacterial wilt, is caused by the bacterium *Erwinia stewartii*, which overwinters in the gut of the corn flea beetle (*Chaetocnema pulicaria*). The occurrence of this disease is strongly linked to the winter survival rate of the corn flea beetle, because the beetle introduces the pathogen into the corn plants as it feeds and carries the bacterium from plant to plant. The beetles survive in high numbers following a mild winter, resulting in high disease levels. If the sum of the mean monthly temperatures for December, January and February is 90°F or more, the beetles will survive and the threat of Stewart's wilt is high. The disease is not spread by insects other than the flea beetle. Stewart's disease is also seedborne, but seed transmission is very rare.

Pest Distribution and Importance:

This disease is more common in the southern and eastern parts of the Corn Belt. Sweet corn hybrids can be very susceptible. The disease systemically infects susceptible hybrids. Therefore, initial infection of seedlings often causes failure of a plant to produce a marketable ear. Yield losses are related to the level of host resistance and growth stage at which plants are infected. This disease is of increasing importance in recent years. Perhaps because more flea beetles are able to overwinter due to mild winter temperatures. Monitoring for flea beetles is important. This disease systemically infects susceptible hybrids, thus, initial infection at seedling stages often causes failure of a plant to produce a viable ear. Crop losses can be up to 90% (following mild winters). Control includes: wilt-resistant hybrids, insecticide use to reduce insect vectoring, and planting between the overwintering and 2nd generation of flea beetles. Stewart's wilt can be managed to a great degree with hybrid selection. Bigger problem as go south until hit a point in the south where it doesn't become a problem anymore. About number 3 in significance of diseases.

Chemical Controls:

- Control flea beetles which is the vector. Cost effective treatments for disease consist of seed treatments - See insecticide section for Cruiser and Gaucho for corn flea beetles.
- **Other pest management aids:**
 - Most cultural practices do not influence Stewart's disease because the pathogen survives in the flea beetle. If flea beetle numbers are extremely high, insecticide applications can reduce the beetle population and disease spread.

Stalk Rots

Biology and Life Cycle:

Stalk rots are caused by several different fungi that infect plants through the roots or through wounds in the stalk. The major stalk rot pathogens are *Gibberella zeae*, *Fusarium* species, and *Colletotrichum graminicola* (anthracnose), and *Diplodia sp.*

Pest Distribution and Importance:

The occurrence of stalk rots is strongly affected by stresses on the corn plant during the grain filling stage of development. Any conditions that reduce photosynthesis and the production of sugars can predispose the plant to severe stalk rot. Such stresses include high plant populations, severe leaf diseases or hail damage, drought or soil saturation, lack of sunlight, extended cool weather, low potassium in relation to nitrogen, and insect damage. Insects such as the European corn borer cause stress to the plant

as well as providing wounds for entrance of the stalk rot fungi. Many stalk rot infections can be traced back to stalk boring insect wounds. Stalk rots are a sporadic and seasonal problem and are generally considered of minor importance in corn production.

Chemical controls:

- None listed.

- **Other pest management aids:**
 - In general, losses to stalk rots can be reduced by scouting fields 40 to 60 days after pollination and looking for symptoms or pinching stalks. If more than 10 to 15 percent of stalks are rotted, the field should be scheduled for the earliest possible harvest. Severe stalk rot can be avoided by reducing the stresses that predispose plants. This means balanced fertilization, appropriate plant population and adapted hybrids, insect and weed control, avoidance of root and stalk injury, good drainage, proper irrigation (where applicable), and using hybrids that are resistant to foliar diseases. Resistance is available for some stalk rots, and some hybrids are tolerant of stalk rots (will not lodge even if rotted).

Ear and Kernel Rots

Biology and Life Cycle:

Fusarium Rots

Fusarium ear and kernel rot is the most common ear disease in the Midwest. It is caused by several fungi in the genus *Fusarium*, but *F. moniliforme* is considered to be the primary species on corn in the Midwest. Fusarium ear rot occurs under a wide range of weather conditions. The fungus causes a stalk rot and can colonize any part of the corn plant, overwintering in the corn residue and on dead grassy weeds. *F. moniliforme* also is commonly found in corn seed. *Fusarium* spores are spread by wind and splashing rain to the silks, which are most susceptible for the first 5 days after they appear. Infections also occur through wounds made by insects or other types of wounds in the kernels. Insects can create wounds in which *Fusarium*. *F. moniliforme* can infect and grow throughout the corn plant, and some ear infections may be the result of the fungus entering the ear through the shank, but infection usually occurs in a silk. Several of the *Fusarium* species causing corn ear rot can produce a harmful mycotoxin, fumonisin, that has been implicated as a cause of human esophageal cancer and has been associated with neural tube birth defects in a Hispanic population that consumes large quantities of corn based products.

11b. Gibberella ear rot

This ear rot is common throughout the Midwest. It is caused by the fungus *Gibberella zeae* which is the sexual reproductive stage of *Fusarium graminearum*. This fungus also causes a stalk rot, and

overwinters in corn residue. The spores are spread by splashing rain and wind infecting ears through the silks. Silks are most susceptible 2 to 6 days after emergence. The disease is favored by warm, wet weather after silking. This may be the most consistently important mycotoxigenic fungus in the northern Corn Belt, producing vomitoxin, zearalenone, and other toxins.

11c. Diplodia ear rot

Diplodia ear rot is caused by the fungus *Diplodia maydis* (*Stenocarpella maydis*), which also causes Diplodia stalk rot. This disease is not typically as common as Fusarium or Gibberella ear rots, but it can be destructive when it occurs. The fungus overwinters as mycelium, spores, and pycnidia on corn residue or seed. The spores are spread primarily by splashing rain. The infection process for this disease is poorly understood, but infections first appear at the base of the ear. Corn borer damage in the shank can provide an entry wound for the pathogen. Diplodia rot is favored by cool, wet weather during kernel fill. Rainfall during August, September, and October is correlated with Diplodia ear rot incidence. *D. maydis* is not known to produce harmful mycotoxins. *Diplodia maydis* usually does its damage in the field, but it can be a problem in storage if grain moisture is 20 percent or above. The incidence of Diplodia has increased in the past ten years along with increased minimum tillage.

Pest Distribution and Importance:

Control of the various ear and kernels rots can be achieved by similar practices. Prevention of their occurrence is difficult because of their dependence on weather and the limited affects of cultural practices. These diseases have a high importance to corn production as the toxins produced by molds can be a serious health issue for humans. Concern over these diseases could rapidly escalate if FDA sets levels for mycotoxins at unachievable levels. Sources of resistance are available in unadapted germ plasm. 11 b and c are both more serious problems in sweet corn than 11a. All have the same problem with minimum tillage; it causes increased problems in sweet corn - increased levels of inoculum. Problem for all three. Serious problem when it appears; which is 4-5 days before harvest.

Chemical controls:

- None listed.
- **Other pest management aids:**
 - Plant more tolerant hybrids. Tolerance to the ear rots varies among hybrids, although complete resistance is not available. Crop rotation can reduce the occurrence of some ear rots, such as Diplodia. Others may not be affected much because of the movement of spores from neighboring fields.. Control of insect and wildlife feeding may reduce ear rots to some extent.

Common leaf rust: [*Puccinia sorghi*]

Biology and life cycle:

The fungus does not overwinter in the Midwest because the final spore stage at the end of a growing season (teliospores) does not infect corn. Urediniospores spread north each season as corn is planted. Thus, rust is of little consequence to early planted sweet corn (or field corn). Each uredinium produces about 5,000 urediniospores, so low levels of infection (2-5% severity) at early growth stages (3- to 4-leaf stages) creates an abundance of inoculum that can cause chemical control to be difficult. Juvenile leaves of corn plants (i.e. the first four or five leaves on a plant) have different morphology than adult plant leaves, and juvenile leaves are more susceptible to rust regardless of the genetic background of the plants. Rust is most severe on late-planted sweet corn because initial inoculum is abundant when plants are at juvenile stages and weather is conducive (cool night, heavy dews) to secondary spread as plants progress from the 5 leaf stage to harvest. This disease is aggravated by: cool temps (65-75 F), light rains, heavy dews, and high humidity. It is spread when the urediniospores are windblown from previously infected leaves.

Distribution and Importance:

Losses range from 0-50% (depending on environment and resistance). Control includes: resistant hybrids and foliar fungicides (RPD: no. 965). Problem on corn planted after June 1. More of a problem south of Central Wisconsin.

Chemical Controls:

- Multiple modes of action are essential for managing resistance development. All currently registered products should remain registered for control of this pest.
- **Triazoles**
 - Propiconazole, (Tilt) Level of control is fair to good, better on NLB than rust. Expensive. Timing of application is critical. The REI is 24hrs and the PHI is 14d.
- **Substituted Benzenes**
 - Chlorothalonil, (Bravo) Level of control is poor to fair. The REI is 48hrs and the PHI is 14d. Not for processed sweet corn.
 - Maneb. Level of control is good. The REI is not indicated and the PHI is not indicated.
- **Strobilurins**
 - Resistance management is key to keep this group.
 - Azoxystrobin (Quadris) . Preferred method of control. Level of control is good to

excellent. The REI is 4hrs And the PHI is 7d

- (Stratego, Flint, F-500). Level of control is excellent

- **Other pest management aids:**

- From the mid-1980s to 1999, rust was controlled in processing sweet corn grown in the Midwest primarily by the use of a single, dominant resistance gene, Rpl-D. Virulence against this. Resistance was widespread in the US for the first time in 1999. Other single gene resistances are being developed and partial (polygenic) resistance is being improved, but the prolonged usefulness of other Rp genes is questionable.

Maize Dwarf Mosaic Virus:

Biology and Life Cycle:

This disease is spread by insect vectors (aphids). Several strains of MDMV (or related sugar cane mosaic virus) occur. Effectiveness of host resistance may be affected by strain. MDMV-A overwinters in Johnsongrass and is most frequent in areas and fields where Johnsongrass occurs. MDM usually occurs in sweet corn with the arrival of aphid vectors in June or July. Early infections may expose sweet corn to root and stalk rots and cause premature death. Symptoms can appear in the field within 30 days after seedling emerge.

Distribution and Importance:

Control includes: resistant hybrids and control of rhizome Johnsongrass or other overwintering weed hosts. Yield losses are affected substantially by growth stage at which plants are infected. Infection of seedling causes the greatest losses. Minor - last three weeks of season, can reduce yield, corn planted after June 15 is at risk. Stunts plants. Fresh market - this is biggest problem in the Ohio River Valley (Johnsongrass a problem because it is the overwintering host) Have to take out aphids when Johnsongrass is killed. One half of the fresh market corn is exposed to MDMV.

Chemical Controls:

- None listed.
- **Other pest management aids:**
 - None listed.

Barley Yellow Dwarf Virus (late season)

Biology and life Cycle

Virus vectored by several species of aphids (*Rhadopalus padi*, *R. maidis*, etc.) Strains of the virus are differentiated by vectors. Late planted sweet corn seems to be infected most frequently. Symptoms appear late in the summer as chlorosis or purpling of leaf margins resembling K or P deficiency.

Distribution and Importance

Occurs sporadically throughout the upper Midwest. Can cause reduction in yield. Lower case recovery - significant problem. More common on late season hybrids - after June 15. Increasing in importance.

Chemical controls:

- None listed.

Table 9. Fungicides, Brand Names, REI and PHIs, and Treatment Estimations

Trade Name	Common Name	REI Hrs	PHI Days	Target Disease	Percent Acres Treated "2003"
Apron	metalaxyl	48	NA	soil borne diseases	99
Bravo	chlorothalonil	48	14		1
Captan 30-DD, Captan 400	captan	96	NA	seed rot, seedling blights, seedborne diseases	20
Gauche Insecticide	imidacloprid			stewart's wilt	1-5
Maxim 4FS	fludioxonil	48	NA	seedling blights	80
Mancozeb Dithane	Mancozeb	24	7		0
Quadris	azoxystrobin	4	7	Leaf rust and N. Corn leaf blight	10
Tilt	propiconazole	24	14	leaf blights, rust	20

Nematodes

Biology and Life Cycle:

Nematodes that attack corn are microscopic roundworms, approximately 3/10 to 3/64 inch long. There are many species of nematodes that feed on corn. Dagger and spiral nematodes may be the most common and widespread nematodes.

Pest Distribution and Importance:

Every cornfield contains nematodes actively feeding on plants. The presence of nematodes depends on the soil type and its properties, other soil microorganisms, cropping history, climatic factors such as temperature and rainfall, tillage practices, and the use of pesticides. Corn nematodes can feed without causing appreciable yield loss if nematode numbers are low and/or the environmental conditions are such that the corn crop is not stressed. Needle nematode probably is the most damaging, but is not widespread. The most important species that is a parasite on corn is the lesion nematode *P. penetrans*.

Nematicides:

Many effective nematicides have been removed from the market and very few new nematicides are being developed, but a few compounds (including some soil insecticides) are still labeled for control of plant-parasitic nematodes on field corn.

Other pest management aids:

Management options for control of nematodes on corn are limited. Cultural control strategies such as crop rotation, delayed planting, and alternative tillage have little effect on corn nematode densities and nematode-resistant corn hybrids are lacking.

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References

1. Data available from the Vegetable Yearbook -Tables 091, 092, and 099 http://usda.mannlib.cornell.edu/data_sets/specialty/89011/
2. <http://www.usda.gov/nass/pubs/agr00/acro00.htm> (Vegetables and Melons)
3. AREI production management, pest management http://www.ers.usda.gov/Emphases/Harmony/issue/arei2000/AREI4_3pestmgt.pdf
4. Estimates given by University and industry specialists in each respective discipline.
5. .All RPDs reference Report on Plant Diseases. Bulletins issued by number by the University of Illinois Department of Crop Sciences, Urbana, Illinois, 61801.

6. University of Minnesota Vegetable Production and Pest Management Website
<http://www.vegedge.umn.edu/vegpest/swtcorn/corn.htm>
7. University of Illinois Sweet Corn Disease Reports (See Pataky above)
<http://www.sweetcorn.uiuc.edu/report2000/> Vegetable Insect Management. Foster & Flood

Appendix

Appendix A. Worker Exposure Table for Processed Sweet Corn

Processed		Figures are relative to a 100 acre field.				
In-field event	Dates of event	Number of people involved in event	Hours per event X number of events	Total event hours per season	Level of exposure per season*	Percent of total area traversed / season
Planting	April 1- July 1	1	8	8	1 hr - loading enclosed cab	100
Irrigation	April 10- Sept 30	1	2 X 5	10	minimal exposure <1 hr	10-15
Scouting weeds	Ap 15 - July 1	1	1	1	1 hr	40*
Scouting insects & Diseases	May 1- Sept 30 (July 20- Aug 30)**	1	.5 X 3	1.5	1.5 hr*	45*
Cultivation	May 1- Aug 1	1	8-10	8-10	minimal exposure <1 hr	80

Pre-grading 10 days to harvest	July 5- Oc t 5	1	.5 X 5	2.5	2.5 hrs, wearing slicker suits	100
chemical app: weeds (ground)	Mar 20- July 30	1	4 X 1-2 apps (avg 1.3)	4-8	variable to min. exp <1 hr	99.5
chemical app: diseases (aerial)	July 1- Sept 1	1	1 X 0-2 (avg 0.1)	0-2	minimal exp <1 hr	5-10
chemical app: insects (aerial)	Jun 1- Sept 15	1	1 X 0-4 (avg. 2.2)	0-4	minimal exp <1 hr	80
harvest- mechanical	July 15 - Oct 15	2	2 X 16	32	minimal exposure<1 hr	100

* Level of Exposure per Season is determined by worker contact with seed, soil, plants, or pesticide aerosols or residues.

Appendix. B. Worker Exposure Table for Fresh Market Sweet Corn.

Fresh Market		Figures are relative to a 100 acre field.				
In-field event	Event dates	Number of people involved in event	Hours per event X number of events	Total event hours per season	Level of exposure per season*	Percent of total area traversed / season
Planting	April 1- July 1	1	8	8	1 hr - loading enclosed cab	100
Irrigation	April 10- Sept 30	1	2 X 5	10	minimal exposure <1 hr	10-15
Scouting weeds	Ap 15 - July 1	1	1 X 2	2	2 hr	100*

Scouting insects & Diseases	May 1- Sept 30 (July 20-Aug 30)**	1	.5 X 6	3	3 hr*	100*
Cultivation	May 1- Aug 1	1	8-10 X 2	16-20	minimal exposure <1 hr	80
chemical app: weeds (ground)	Mar 20- July 30	1	4 X 1-2 apps (avg 1.3)	4-8	variable to min. exp <1 hr	99.5
chemical app: diseases (aerial)	July 1- Sept 1	1	1 X 2	2	minimal exp <1 hr	50
chemical app: insects (aerial)	Jun 1- Sept 15	1	1 X 5-7 (avg. 6)	5-7	minimal exp <1 hr	100
harvest - hand	July 8- Sept 15	19	80 X 19	1520	1520	50
harvest-mechanical	July 8 - Sept 15	2	2 X 16	32	minimal exposure <1 hr	50

Appendix H. Distribution Maps of Production and Pests of Sweet Corn

Production Regions for

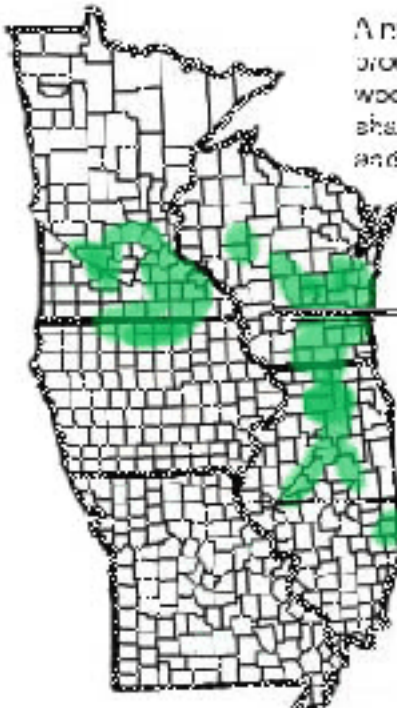
Fresh Market Sweet Corn



Processed Sweet Corn



Weed Distribution in Sweet Corn Production Areas

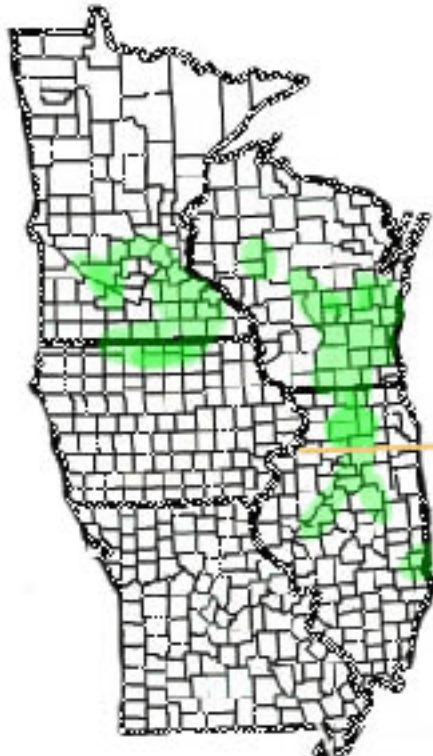


A number of weeds are found throughout the sweet corn production area. These weeds include: foxtails, crabgrass, woolly cupgrass, barnyardgrass, nuttall's, field sandbar, shattercane, bromegrasses, common milkweed, common and giant ragweed, horseweed, henbit, mustards, pigweeds, lambsquarters, velvetleaf, waterhemp, and horseweed. Exceptions to this general distribution are as noted below.

South of this line quackgrass is seldom a problem. North of this line tall panicum, western muhly, bluegrass, field bindweed, morning glories, pokeweed and horseweed are seldom significant problems.

North of this line Johnsongrass is seldom a problem.

Disease Distribution in the Sweet Corn Growing Regions



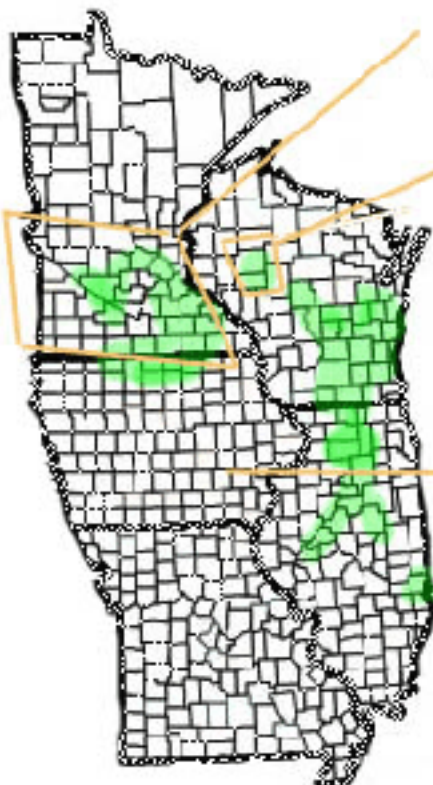
Most sweet corn diseases are common throughout the growing region. These diseases include: seed decay and seedling blights, root rots, eyespot, Northern corn leaf spot, anthracnose leaf blight, gray leaf spot, stalk rots, ear and kernel rots, barley yellow dwarf virus, and nematodes.

Leaf rust, Northern corn leaf blight, common smut, and Maize Dwarf Mosaic Virus (MDMV) tend to be more of a problem south of Interstate 80.

Stewart's wilt, which is associated with corn flea beetles, is generally found south of this line.

Light green areas indicate sweet corn production areas.

Insect Distribution in Sweet Corn Growing Regions



Univoltine and bivoltine European Corn Borer result in continuous flights throughout the season. Western bean cutworm is also common in this area.

Area where seed corn maggot is most prevalent.

Except as indicated in the statements above and below, most sweet corn insects are found throughout the production area. Common insect pests include: white grubs, corn rootworms, corn earworms, cutworms, hop vine borers, spider mites, grasshoppers, Japanese beetles, and sap beetles.

Corn rootworm adults more of a problem north of the line.

Flea beetles and southwest corn borer more of a problem south of this line.

Light green areas are regions where sweet corn is grown for processing.