Sweet Corn
Pest Management Strategic Plan
(Northeastern States)

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Executive Summary

Collectively, the 11 northeastern states produce 22.9 percent of the total U.S. crop of fresh market corn and approximately 14.1 percent of the processed corn in the country. Regionally, sweet corn is grown on approximately 110,800 acres, represents 30 percent of the vegetable crop acreage, and is grown by 50 percent of the nearly 6,000 vegetable farmers in the region (2002 Census). Fresh market corn represents approximately 74,400 acres, while processing corn is grown on 36,400 acres (2002 Census). The largest producing states in the northeast for fresh market corn are New York (28,000 acres) and Pennsylvania (19,600 acres). Of the northeastern states surveyed by National Agricultural Statistics Service (NASS) that produce sweet corn for processing, New York produces just over one-half (110,200 tons) of all of the processed sweet corn grown in the region, with Delaware coming in a distant second (49,020 tons). Total value of sweet corn in the northeastern states is $157,951,000 for fresh market corn and $29,110,000 for processed corn.

The original draft of this Pest Management Strategic Plan (PMSP) was developed from input provided by land grant commodity specialists, sweet corn producers, and industry representatives at a workshop held in December 2004. Participants who attended the workshop are listed on pages 3–4 of this document. Further development of the PMSP was based on grower input gathered from two additional sources: a survey of New England sweet corn growers conducted by the University of Massachusetts in 2004 (n= 215) and a NASS survey of growers in Pennsylvania, New York, and New Jersey (n=250). Throughout this document, information from all three sources is presented to illustrate the pest management issues that growers face, a field-based perspective of actual chemical use, and grower perspectives of the effectiveness of the chemical control options. While pest conditions and pest management practices differ among states and geographic areas within the region, we have found that there are consistent patterns and needs.

The content of this document regarding production and pest management practices and products for sweet corn is based on many reliable sources, but the primary sources of information came from the *New England Vegetable Pest Management Guide* and the *Pennsylvania Commercial Vegetable Production Recommendations.* Additional material was adapted, with permission, from the *North Central States Sweet Corn PMSP.*

Growers indicated that the major caterpillar pests (corn earworm, European corn borer, fall armyworm) along with corn leaf aphid present their biggest challenge in insect pest management. The predominance of synthetic pyrethroids, and to some extent the carbamates among the insecticides that are available—and are considered effective—is a major concern. Growers indicated a strong need for alternatives that provide a different chemistry; are effective, reasonably priced, and safe for handlers; and have less impact on natural enemies. Until these are available, maintaining current registrations for non-pyrethroid products is important.

Alternatives that are highlighted in the recommendations include alternative chemistries, biological control, and transgenic (Bt) cultivars. Growers also have a need for resources and tools to enable them to implement IPM practices throughout the region at the farm level, regardless of farm size or location. The challenges facing organic sweet corn producers are also discussed in this PMSP.

Weed management in sweet corn requires herbicides that will effectively control annual broadleaves, grasses, and perennial broadleaf weeds. When asked to rank the weed pests requiring the most management, 91 percent of the 209 New England growers who responded ranked annual broadleaf weeds as the most significant weed pest. Eighty percent felt that annual grasses were the most significant weed problem, followed by perennial broadleaf weeds at 58 percent and perennial grasses at 54 percent. New chemical control options are needed for weeds, including short residual herbicides, and both pre- and post emergence options. Until new chemistries are available, registrations for critical uses should be maintained. Cultivation is widely used as a supplement to herbicides, and organic farmers depend upon cost-effective cultural and mechanical methods for weed control.

Management of insect and weed pest problems often has an effect on the presence of disease problems. Although the use of seed treatments and resistant varieties has dramatically reduced the incidence of many sweet corn disease problems, several diseases still present potentially significant economic losses if not properly managed. Growers indicated that Stewart's wilt, common leaf rust, common smut, and stalk rots are the most important diseases in terms of the percentage of acres infested.

Vertebrate pests cause significant losses. Birds, raccoons, and deer were ranked as the most serious pests. A variety of control methods and repellents are used with varying effectiveness. Growers noted the need for effective seed treatments against bird pests of seeds and seedlings.

Within the context of the Sweet Corn PMSP, workshop participants discussed their greatest pest management challenges and outlined their priorities for regulatory, research, and education action. Pages 5–7 indicate these priorities facing sweet corn producers, based on the consensus of those present at the Sweet Corn PMSP workshop.

General Discussion and Recommendations

- Healthy soils are important for general plant health and pest resistance.
- Adjusting the planting date (early or late) can be used to avoid several pests; however, it can lead to a problem with establishment of the crop or pressure from other pests, and it is not always economically feasible.
- The need for succession planting to provide continuous market availability creates challenges for pest management practices, which must respond to changes in environment and pest pressure over the course of the season.
- The overwintering range of some pests seems to be expanding.
- Transgenic sweet corn cultivars are available for control of some corn insect pests; however, increased public acceptance of genetically modified crops is critical to their potential impact.
- Transgenic sweet corn cultivars are not available in some parts of the region or to some growers due to regulatory restrictions, including organic restrictions.
- Lack of an adequate number of experienced extension personnel, scouts, and consultants is a limiting factor in the implementation of IPM throughout the region.
- Irrigation is a cultural practice that contributes to the effective management of pests and the production of a high-quality crop. Depending on weather conditions, the majority of sweet corn production acreage in the region is set up for irrigation during dry periods.
- Maintaining availability of different types of chemistries for pest management options is critical to resistance management.

Priorities for Regulation, Research, and Education

Regulatory Priorities

Major Insect Pests (Lepidoptera)

- Register (and re-register) different/additional chemical families for Lepidopteran pests. For corn earworm, which is the most destructive corn ear pest, six of the nine chemicals registered are pyrethroids, which could lead to resistance in pest populations. These are also the most widely used. Resistance management is an important issue for effective pest management, and alternative chemistries are critical to resistance management.
- Maintain registrations for nonpyrethroid products, including the current methomyl registration.
- Register control methods that will not negatively affect beneficial insect populations.
- Reduce regulatory barriers for access and distribution of biological organisms (e.g., *Trichogramma ostriniae*).

Weeds

- Maintain herbicide registrations for critical uses:
  - Triazines – Broadleaf weeds
  - Sutan+ – Johnsongrass
  - Eradicane – Johnsongrass

Minor Pests

- Maintain labeled use for Diazinon as a soil-applied and incorporated material; soil insects are not adequately controlled by other presently labeled products.
- Register new products (e.g., neonicotinoids) for corn leaf aphid.
- Maintain Metasystox R registration (which is used as a rescue treatment primarily in the southern part of the region in rare instances of mite outbreak) until a viable alternative is labeled for sweet corn.
- Register new lower risk chemistry products for twospotted spider mite control.
- Register spinosad (trade names SpinTor 2 SC, Entrust) for flea beetle control. Entrust registration would be especially important for organic growers.
- Establish a mechanism that facilitates management of damaging bird populations.
- Register seed treatments for bird control.

Research Priorities

Insect management

- Management of corn earworm and other Lepidoptera with less reliance on pyrethroids:
  - Alternatives to the current pyrethroids for larval control, due to potential suspected resistance, declining efficacy, and negative effects on beneficials.
  - Research ecological/biological management of European corn borer and other Lepidoptera.
- Determine how to make the best use of transgenic cultivars (Bt hybrids) in an integrated pest management approach. Evaluate effects of regional Bt field corn use on sweet corn pest populations and beneficial insect populations.
- Work on resistance management for spinosad and other materials approved for organic growers.
- Determine effective management systems for using *T. ostriniae* to control European corn borer in all northeastern sweet corn growing areas.
- Conduct research on how to preserve natural enemies to pests, including effects of insecticide and fungicide chemistries on beneficial populations and effects of beneficial populations on pest populations.
- Develop pest prediction modeling to complement in-field scouting and thresholds.
  - Develop or refine phenology models for key pests such as European corn borer, corn leaf aphid, corn earworm, and sap beetle.
  - Improve prediction capabilities that enable growers to make site-specific decisions by using action thresholds.
- Document pyrethroid resistance development, especially in Lepidopteran pests.

- Conduct research on the control of soil-borne insects and seed pests, such as seedcorn maggot, to replace Diazinon.
- Conduct research on control for mites, including twospotted spider mite, by using oil sprays or other safer alternatives to replace Metasystox R. Good control methods are not available for mite infestations, and the new products are prohibitively expensive.
- Develop alternative chemicals for aphid control.
- Develop seed treatment or other effective strategies for bird control.

Weed management

- Develop new chemical control options for weeds, including a short residual herbicide for double-cropping systems (two crops planted in the same year) because Bladex is no longer available.
- Alternative weed control strategies for organic production.
- Develop post emergence annual and perennial grass herbicides.

Educational Outreach Priorities

- Ensure that growers understand how new chemistries (such as Callisto 4F or Aim) are labeled and recommended. Emphasis should be on how use and recommendations for sweet corn differ from the field corn label recommendations-critical for decreasing the potential for severe crop injury.
- Increase the number of people in the field who are trained in integrated pest management (IPM) to help growers monitor pest populations.
    - Develop monitoring programs; obtain infrastructure for scouting and monitoring programs relevant to diversified and small growers across the northeast.
    - Educate growers about predictor models for European corn borer.
- Information transfer concerning beneficial insects, for both organic and IPM systems.
    - Education on how and why to preserve beneficial insects and how to use other ecological/biological approaches to managing pests.
    - Provide information on the toxicity of pest control measures and pesticide chemistries to beneficial insects, bees, workers, soil, and water.
    - Education on the impact of transgenic cultivars (Bt hybrids) on beneficials.
- Education on insect and disease identification.
    - Create a pictorial field guide with all sweet corn pests, including leaf diseases and insects. Growers liked the New England calendar-type color picture guide to vegetable pests.
    - Include more hands-on insect identification and biology at grower meetings.
- Provide training on alternative weed control methods, especially alternatives to atrazine that are registered but not generally used.
- Market IPM to increase consumer demand for IPM and locally grown products and to make the public aware of the other benefits resulting from IPM implementation.

- Provide information to growers about the development and prevention of resistance in pest populations across the region, especially in the early stages when resistance is first observed.

Background and Introduction

The most important aspect of the development of this Sweet Corn Pest Management Strategic Plan was input from the growers. The original draft of this Pest Management Strategic Plan (PMSP) was developed from input provided by sweet corn producers, land grant commodity specialists, and industry representatives at a workshop held in December 2004. Participants who attended the workshop are listed at the beginning of this document.

Further development of the PMSP was based on grower input gathered from two additional sources: a survey of New England sweet corn growers conducted by the University of Massachusetts in 2004 and a National Agricultural Statistics Service (NASS) survey of growers in Pennsylvania, New York, and New Jersey. We believe that together these three sources provide an accurate representation of the range of farms, farmers, and geographical variations within the region.

The sweet corn pest management survey was completed by 215 New England sweet corn growers in fall of 2004. The survey was conducted by mail using the Dillman method, and was distributed to 754 New England sweet corn growers. Percentages of growers responding are calculated using the number of growers who responded to the survey as the denominator, not the number of growers responding to a particular question. Many questions allowed for multiple answers; thus, the percentage of responses may sum to more than 100 percent.

Chemical use data were collected by NASS from 250 sweet corn growers in New Jersey, New York, and Pennsylvania. Enumerators trained by the state divisions of NASS conducted on-farm surveys to collect the data.

Several topics were of particular importance to the participants of the PMSP workshop. These are included as subsections below, and include seed treatments, transgenic cultivars, and organic production.

Throughout this document, information from these sources is presented to illustrate the pest management issues that growers face, a field based perspective of actual chemical use, and a grower perspective of the effectiveness of the chemical control options. Each pest section that follows contains tables that indicate specific grower input from our three primary sources.

Financial Impact of Sweet Corn Production

According to NASS, just over 650,000 acres of sweet corn was harvested in the United States in 2004. Processed sweet corn accounts for 405,800 acres of that total with the remaining 246,200 acres harvested as fresh market sweet corn. The total value of the 2004 U.S. sweet corn crop was almost $648 million. The fresh market crop represents approximately $618 million of the overall value, and processed corn represents just over $29 million of the total.

Collectively, the 11 northeastern states produce 22.9 percent of the total U.S. crop of fresh market corn and approximately 14.1 percent of the processed corn in the country. Sweet corn has the largest acreage of any vegetable crop, and is grown by a higher percentage of vegetable farmers than any other vegetable crop. Regionally, sweet corn is grown on approximately 110,800 acres, represents 30 percent of the vegetable crop acreage and is grown by 50 percent of the nearly 6,000 vegetable farmers in the region (2002 Census). More than any other single vegetable crop, sweet corn plays a vital role in many types of farms, from large-scale farms growing for wholesale and processing to small diversified farms producing for direct markets. Thus the needs and priorities that are documented here represent the wide range of vegetable growers in the region.

Fresh market corn represents approximately 74,400 acres while processing corn is grown on 36,400 acres (2002 Census). The largest producing states in the northeast for fresh market corn are New York (28,000 acres) and Pennsylvania (19,600 acres). Of the northeastern states surveyed by National Agricultural Statistics Service (NASS) that produce sweet corn for processing, New York produces just over one-half (110,200 tons) of all of the processed sweet corn grown in the region, with Delaware coming in a distant second (49,020 tons). Total value of sweet corn in the northeastern states is $157,951,000 for fresh market corn and $29,110,000 for processed corn.

Tables 1–6 provide details on fresh market and processed sweet corn value, acreage, and yield and production for the 11 northeastern states.

Table 1. Fresh market corn value by state[1]

State	2002 ($/CWT)	2003 ($/CWT)	2004 ($/CWT)	2002 Total (1,000 $)	2003 Total (1,000 $)	2004 Total (1,000 $)
Connecticut	25.00	27.50	31.00	7,700	6,765	10,664
Delaware	19.00	25.00	20.00	4,522	4,725	7,260
Maine	34.00	32.50	33.00	3,740	3,900	3,960
Maryland	22.00	19.00	20.00	5,500	5,111	6,300
Massachusetts	30.00	31.50	32.50	11,970	13,230	16,965
New Hampshire	42.50	42.00	42.00	3,613	5,586	5,292
New Jersey	21.80	23.90	20.80	17,244	12,117	10,920
New York	23.90	20.60	21.40	78,344	84,336	59,920
Pennsylvania	31.80	24.90	22.10	22,133	29,033	30,763
Rhode Island	31.00	31.00	38.00	1,984	2,790	3,762
Vermont	34.50	36.00	39.00	1,656	3,168	2,145
Subtotal Northeastern States				158,406	170,761	157,951
Total Value U.S. Production				509,421	550,528	618,790

[1]Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.

Table 2. Fresh market sweet corn acreage by state[1]

State	2002 Acres Planted	2003 Acres Planted	2004 Acres Planted	2002 Acres Harvested	2003 Acres Harvested	2004 Acres Harvested
Connecticut	5,500	5,000	4,700	4,400	4,100	4,300
Delaware	3,000	3,400	3,600	2,800	3,000	3,300
Maine	2,400	2,200	2,300	2,000	2,000	2,000
Maryland	5,300	4,700	4,700	5,000	4,200	4,500
Massachusetts	6,600	6,200	6,300	5,700	5,600	5,800
New Hampshire	2,100	2,100	2,000	1,700	1,900	1,800
New Jersey	9,000	8,500	8,200	8,500	7,800	7,500
New York	31,000	39,100	29,000	29,800	35,600	28,000
Pennsylvania	21,200	20,900	21,800	17,400	18,800	19,600
Rhode Island	1,100	1,100	1,200	980	1,000	1,100
Vermont	1,100	1,200	1,200	950	1,100	1,000
Subtotal Northeastern States	87,200	93,200	83,800	78,280	84,000	77,900
Total U.S. Acreage	264,300	271,500	260,400	245,730	246,800	246,200

[1]Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.

Table 3. Fresh market sweet corn yield and production by state[1]

State	2002 Yield/Acre (CWT)	2003 Yield/Acre (CWT)	2004 Yield/Acre (CWT)	2002 Total Production (1,000 CWT)	2003 Total Production (1,000 CWT)	2004 Total Production (1,000 CWT)
Connecticut	70	60	80	308	246	344
Delaware	85	63	110	238	189	363
Maine	55	60	60	110	120	120
Maryland	50	64	70	250	269	315
Massachusetts	70	75	90	399	420	522
New Hampshire	50	70	70	85	133	126
New Jersey	93	65	70	791	507	525
New York	110	115	100	3,278	4,094	2,800
Pennsylvania	40	62	71	696	1,166	1,392
Rhode Island	65	90	90	64	90	99
Vermont	50	80	55	48	88	55
Subtotal Northeastern States				6,267	7,322	6,661
Total U.S. Production				26,480	28,503	29,110

[1]Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.

Table 4. Processed sweet corn value by state[1]

State	2002/Ton ($)	2003/Ton ($	2004/Ton ($)	2002 Total (1,000 $)	2003 Total (1,000 $)	2004 Total (1,000 $)
Delaware		98.00	78.00		5,527	3,823
Maryland		93.10	98.00		2,887	4,528
New York	69.70	78.40	77.70	6,206	8,523	8,563
Pennsylvania	77.30	85.90	94.20	515	341	753
Subtotal Northeastern States				6,721	17,278	17,667
Total U.S. Production				26,480	28,530	29,110

[1]Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.

Table 5. Processed sweet corn acreage by state[1]

State	2002 Acres Planted	2003 Acres Planted	2004 Acres Planted	2002 Acres Harvested	2003 Acres Harvested	2004 Acres Harvested
Delaware		9,400	7,300		9,400	7,300
Maryland		5,500	6,500		5,500	6,500
New York	17,600	16,300	19,500	16,800	14,400	19,000
Pennsylvania	1,400	1,200	1,700	1,400	770	1,700
Subtotal Northeastern States	19,000	32,400	35,000	18,200	30,070	34,500
Total U.S. Acreage	442,000	438,300	412,700	417,100	426,600	405,800

[1]Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.

Table 6. Processed sweet corn yield and production by state[1]

State	2002 Yield/Acre (Tons)	2003 Yield/Acre (Tons)	2004 Yield/Acre (Tons)	2002 Production (Tons)	2003 Production (Tons)	2004 Production (Tons)
Delaware		6	6.72		56,400	49,020
Maryland		5.64	7.11		31,000	46,200
New York	5.3	7.55	5.8	89,040	108,780	110,200
Pennsylvania	4.76	5.16	4.7	6,600	3,970	7,990
Subtotal Northeastern States				95,640	200,150	213,410
Total U.S. Production				1,639,690	1,709,740	1,509,910

[1]Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.

Table 7. Snapshot of market outlets used by 213 New England growers who responded to an inquiry regarding distribution of their crop

Market	# Acres	% Acres
Fresh market, retail	2,405	54
Fresh market, wholesale	1,964	44
Processing	0.6	<1
Other*	17	<1

*Community Supported Agriculture (CSA), Farmers' Market, and U-Pick.

Seed Treatments

Seed producers determine what chemicals are used as a seed treatment on seed corn. Seed treated with neonicotinoids makes no guarantee of germination of carryover seed due to seed quality and storage; therefore, seed distributors do not want to overtreat their stock, nor do growers want to end the planting season with treated seed. Seed is available that is commercially treated with one or more of the following fungicides: Apron XL LS, Imazalil, or Maxim. Seed that is commercially treated with Lorsban 50 SL, Poncho 600, Cruiser 5FS, or Gaucho 480 will provide seed and seedling protection from seed corn maggot and wireworm damage. Cruiser, Gaucho, and Poncho also will help provide control of flea beetles. However, some of these chemicals have rotational restrictions that influence growers' decisions during seed selection, because of growers concerns that rotational restrictions may limit chemical use in some double crop vegetable production systems. A planter hopper box treatment would help to prevent pests on untreated seed corn while allowing stored seed to remain untreated. Imidacloprind hopper box treatments are available (e.g., Latitude), however, distribution is a problem.

Resistance management of new seed treatments must be considered, especially with some of the systemic chemistry that is more susceptible to resistance development. Use of neonicotinoid commercially applied seed treatment in field corn seed is increasing rapidly, and targets the same pest complex. This trend also is occurring with sweet corn in the Mid-Atlantic region, which increases the potential for target pests to develop resistance.

Organic Sweet Corn Production

Pest management in organic sweet corn production relies on several methods to control weeds and maintain insect pest populations below economic and aesthetic threshold levels. Pest management tools on which organic growers depend include the following.

Cultural practices: crop rotation; tillage of previous residues to kill overwintering pests; mechanical cultivation with a range of tools to control weeds, from preplant through whorl stage; flame weeders used preplant or preemergence; use of transplants to avoid early season seedling pests and to get ahead of weeds; and floating row covers as insect barriers and growth enhancers. The planting date also may be used to avoid pests. Providing adequate nutrients from organic sources and soil fertility are key to crop vigor and growth.

Genetic control: variety selection for seedling and plant vigor and for ear characteristics that reduce infestation with ear-invading pests, such as length of the tip cover at the end of the husk and tightness of the silk channel.

Field scouting and use of pheromone traps are used to determine the need and best timing for release of beneficial insects, use of sprays (based on thresholds), or oil direct silk application.

Biological control: releasing *Trichogramma ostriniae*, an egg parasitoid of European corn borer, or other beneficial insects, and conserving endemic beneficials through selection of reduced-risk products. The latter is particularly important in aphid control, as no cost-effective insecticides for organic control of aphids in sweet corn exist.

Foliar sprays with organically allowed insecticides: The most widely used sprays include formulations of Bt and spinosad for control of European corn borer, fall armyworm, or corn earworm. Organic growers must be cautious because certain Bt products are prohibited by some of the certifying agencies, either because of they contain prohibited inert ingredients or because of the type of genetic engineering used in manufacturing is prohibited. The spinosad formulation Entrust is allowed.

Use of corn or soy oil, usually mixed with Bt, as a direct silk application immediately after pollination to prevent tip-invading pests, especially corn earworm is allowed. This method requires a single hand application of a small amount of oil (0.5 ml) to each ear and is made more feasible and cost-effective by use of tools such as the Zea-later, which is commercially available. This practice is most suitable for small- to moderate-sized farms with succession planted sweet corn crops for fresh market.

Table 8. Bt-based bioinsecticides for Lepidopteran pests in sweet corn[2]

Source B.t. strain	***B. t. kurstalki***			***B. t. aizawi***				
Trade name	Crymax	Deliver*	Lepinox	Dipel**	Biobit*	Javelin*	Agree*	XenTari*
Manufacturer	Certis	Certis	Certis	Valent	Valent	Certis	Certis	Valent
Formulations			WDG	DF, ES	HP	WG	WG	
				10G				
				SG Plus				
OMRI Listed?*	NO	YES	NO	DF only	YES	YES	YES	YES
Crop & Pest								
Sweet Corn Pests								
Armyworms (general)	X	X	X	X	X	X		X
Fall armyworm			X					
Corn earworm		X				X		X
European corn borer	X	X	X	X		X	X	X

*Agree, Biobit, Deliver, Dipel DF, Javelin and XenTari approved for organic use.
**Not all formulations are labeled for all pests listed. Check label for each formulation.
[2]Source: New England Vegetable Management Guide, 2006–2007.

Genetically Engineered Sweet Corn

Bt use in sweet corn pest management

Bacillus thuringiensis, a bacterial pathogen of certain insect species and life stages, is the oldest, most well known, and well developed of the biological insecticides (Table 8). This bacterium produces a crystal protein that, when ingested, causes degradation of the insect gut and death. Bt strains (also know as subspecies or varieties) are active against particular groups of insects, primarily in the immature stages. For example, B.t. kurstaki and B.t. aizawi are active against caterpillars; however, they differ in which caterpillars are most susceptible. The genes that produce these active proteins have been incorporated using genetic engineering techniques along with traditional breeding methods into several sweet corn varieties. Genes are characterized by the type of crystal protein that they produce.

Several varieties of Bt sweet corn, sold under the trade name Attribute, are now commercially available if purchased in minimum amounts that can range from 9 – 35 pounds. They tend to be varieties more suited to processing than fresh market; however, growers are using them for both types of markets. Although transgenic sweet corn cultivars are available and in use, the existing survey data do not indicate the extent, acceptance, or impact of their use. Bt corn, along with other genetically engineered crops, is prohibited from use on organic farms.

The level of gene expression (to produce Bt in plant tissues) in sweet corn is high in leaves, tassels, husks, and corn silks, and Bt also is present, although at lower levels, in kernels. Current sweet corn varieties have demonstrated high levels of efficacy against the major worm pests, especially corn earworm and European corn borer; and somewhat lower efficacy against beet and fall armyworm. Control of corn earworm varies, and under heavy pressure control is not adequate. Bt corn hybrids that use the CryIA(b) and CryIA(c) are not effective against black cutworm larvae. They also have no impact on sap beetles. This beetle pest can be serious when not controlled by sprays targeting caterpillar pests. For growers using the Bt varieties, a different approach to scouting and thresholds and different timing of insecticides are needed.

At the federal level, Bt corn is not regulated as a pesticide, and most states follow that approach. However, in Maine, the Maine Board of Pesticides Control regulates all pesticides, including plants genetically engineered to produce pesticides such as Bt corn. They require the plant seed producer to apply to register that any pesticide-expressing plants as a pesticide and the Board reviews each application on a case-by-case basis. Several years ago, an application was made by a Bt field corn seed company to register that product for sale in Maine. The Board of Pesticides denied that request based on its determination that there is not a proven need for the product in Maine (based on pesticide use information provided by growers and extension specialists indicating that insecticides are rarely applied to that crop in Maine). No attempts to seek registration for any Bt sweet corn seed have been submitted, but if a company does seek registration in the future, the Board of Pesticides will consider that application on its own merits.

Insect Pests

A successful insect management program can best be accomplished by combining IPM techniques, such as accurate pest identification, scouting, monitoring, and action thresholds, with biological and alternative (preventative) control practices and selective insecticide applications. Growers are aware of the need to alternate between insecticide classes or families to help manage insect resistance and to extend the life of available products. All insects have natural enemies that, if conserved, can help regulate pest populations. Use of selective insecticides that spare beneficial organisms and target the pest to be controlled may also reduce the need for chemical controls. Information in this section describes insect pests that require management in sweet corn (Tables 9–12), the distribution and importance of the pest, and nonchemical and chemical control options (Table 13) on a pest-by-pest basis.

Table 9. Ranking of pests requiring the most frequent management based on responses from 212 New England growers

Rank	Insect/Mite
1	Corn earworm
2	European corn borer
3	Fall armyworm
4	Corn leaf aphid
5	Common armyworm
6	Stalk borer
7	Cutworms
8	Seed corn maggot
9	Corn flea beetle
10	Japanese beetle
11	Sap/picnic beetle
12	Wireworm
13	Twospotted spider mite

Table 10. Ranking of key pests requiring the most frequent management in northeastern U.S. sweet corn, based on comments from participants in the Sweet Corn PMSP workshop

Rank	Insect/Mite
1	European corn borer
2	Corn earworm
3	Fall armyworm
4	Corn leaf aphid
5	Seed corn maggot
6	Common armyworm
7	Cutworm
8	Corn flea beetle
9	Sap/picnic beetle
10	Japanese beetle
12	Wireworm
13	Twospotted spider mite
14	Stalk borer

Table 11. Responses of New England growers indicating percentage of growers using a chemical control, number of acres treated, and percentage of the total sweet corn crop treated for a specific pest

Insect Pest	# of Growers Responding	% Growers Using Chemical Control*	Acres Treated	% Total Sweet Corn Crop Treated
Corn earworm	210	85	3617	81
European corn borer	210	85	3,459	77
Fall armyworm	210	60	1,673	37
Corn leaf aphid	209	29	1,313	29
Seedcorn maggot	207	23	1,269	28
Stalk borer	215	15	515	12
Flea beetle	206	11	468	10
Sap/picnic beetle	206	8	366	8
Japanese beetle	206	7	91	2
Wireworm	207	5	195	4
Twospotted spider mite	205	<1	15	<1

Table 12. Percentage of sweet corn acres damaged by insect pests, in northeastern U.S. sweet corn, based perceptions of participants at the Sweet Corn PMSP workshop

Insect Pest	% Acres Damaged													
	Perception of participant													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Japanese beetle grub	0				10		90	0					<5	
Black cutworm	0				10		10	10		10			5–10	
Corn rootworm	0						0	30			<10			
Cutworms					40		10	10						
Flea beetles	0	<10		5	60		90	0–100						
Seedcorn maggot	0				80		100	10						
True white grub	0				10		90	0						
Wireworm	0	25	10		5		90	0						
Aphids	5	50		40	90		<5	<10						
Corn leaf aphid	0	50			90		<5	50						
Grasshopper	0	0			5		<5	0						
Stalk borer	0						10	0						
Twospotted spider mite	0	0					<5	10						
Corn earworm	60	100	90	100	100		100	30			100			

Table 12 (continued) of sweet corn acres damaged by insect pests, in northeastern U.S. sweet corn, based perceptions of participants at the Sweet Corn PMSP workshop

European corn borer	60	100	90	80	100		100	100						
Fall armyworm	60	60		50	80		50	30						
Japanese beetle adult	0	0			80		2	0						
Picnic beetle	0	0					0	10						
Sap beetle	0	0			80		80							

Table 13. Chemical control for insect pests in sweet corn production[3]

Insect Pest and Chemical Control					
Corn Earworm Ambush-Pounce Asana Baythroid Capture Dipel Entrust Golden Natural Spray Oil Lannate Larvin Mustang Sevin SpinTor Warrior	**European Corn Borer** Ambush-Pounce Asana Avaunt Baythroid Capture Diazinon Dipel Entrust Lannate Larvin Intrepid Mustang SpinTor Warrior	**Fall Armyworm** Ambush- Pounce Asana Avaunt Baythroid Capture Dipel Entrust Lannate Larvin Mustang SpinTor[NL] Warrior	**Aphids** Ambush-Pounce Asana Baythroid Gaucho Lannate Metasystox R Thionex Warrior	**Flea Beetle** Ambush-Pounce Asana Counter Cruiser Furadan Gaucho Warrior	**Seed Corn Maggot** Capture Counter Cruiser Diazinon Force Furadan Gaucho Lorsban

[3]Source: Sweet Corn PMSP workshop participants. NL, not labeled.
*Due to bee toxicity cannot be used during tasseling and pollen shed.
**Available only as a commercially applied seed treatment and treated areas may be subject to rotational restrictions.

Ear-Damaging Pests: European Corn Borer (ECB), Corn Earworm (CEW), and Fall Armyworm (FAW)

Pests that invade the ear are the most important consideration in sweet corn pest management because consumer demand dictates that very little damage can be tolerated. Most processors can accept no more than 5 percent of ears with severe damage at the tip and no more than 1 percent of ears with side-kernel damage before the grading of corn is affected. Severe tip damage is defined as having about an inch of the tip affected. Up to 20 percent of ears with very minor tip injury (0.25 inch or less) are acceptable to most processors. In all cases, the amount of damage accepted depends on the sweet corn variety and the needs of the customer. Damage tolerance is generally much lower for fresh market sweet corn. Growers need to obtain 95–98 percent clean ears. ECB, CEW, and FAW are the major ear-invading pests throughout the Northeastern region, and they are a major focus of IPM programs. Treatment recommendations are based on larvae present during whorl and tasseling stages, before larvae invade the ears, and on blacklight or pheromone trap catches of adult moths.

Application technology for insecticide application against ear-invading pests

The most effective spray equipment for insect control on sweet corn directs the spray to the part of the plant that needs protecting. For whorl sprays, a single nozzle directed over the row is adequate, preferably with high pressure (>75 psi). For pretassel sprays, the best control is achieved by directing one nozzle to the tassel and a single drop nozzle to the upper parts of the plant. Once ears start to form, it is better to direct spray to young ears and leaf bases and to maintain good coverage of silk and husk. Drop nozzles with one or two sets of nozzles aimed directly at the ear zone provide the most thorough coverage. Airblast sprayers can be faster, safer on uneven terrain, and more versatile on diversified farms than boom sprayers; however, they are less effective in concentrating spray on the target. Table 14 indicates that, in New England, the most commonly used pesticide application equipment is a boom sprayer with or without drop nozzles and the airblast sprayer. Comments from those present at the Sweet Corn PMSP workshop indicated that coverage on the silk is most important for all chemical control. They also noted that sprayer variation can impact the success of the control and also that many small producers do not have sprayers. Aerial application is used more widely on processing corn.

Table 14. Type of application used for chemical treatment of sweet corn (the 199 growers who responded to this question indicated more than one type of equipment)

# Growers	% Growers	Pesticide Application Equipment
106	49	Boom sprayer without drop nozzles
81	38	Air blast sprayer
51	24	Boom spray with drop nozzles
38	18	Back pack sprayer
11	5	Zea-later (or other oil applicator)
3	1	Shielded sprayer
2	1	Air-assisted sprayer
12	6	Other

Insecticide use data

The information in Tables 15–18 indicates the overall total percentage of fields treated with insecticides; the amount of insecticides used in New Jersey, New York, and Pennsylvania for fresh market sweet corn production; and the total amounts specific insecticides used in each state. Because of the small sample size of growers who produce sweet corn for processing, data for insecticide use on processed sweet corn are only available for New York. Table 19 indicates the amounts of specific insecticides used in New York for processed sweet corn production. Data on amounts of insecticides used in the New England states are discussed on a per pest basis.

Table 15. New York, New Jersey, and Pennsylvania overall insecticide use in fresh sweet corn[1]

State	2004 Acres Planted	% of Fields Treated with Insecticides[2]
New Jersey	8,200	88
New York	29,000	77
Pennsylvania	21,800	88

[1]Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.
[2]Total applied excludes *B. thuringiensis*. Quantities are not available because amounts of active ingredient are not comparable between products.

Table 16. Specific insecticide use patterns in New Jersey fresh market sweet corn[1,2]

Active Ingredient	Area Applied (%)	Applications (#)	Rate/Application (Pounds/Acre)	Rate/ Crop Year (Pounds/ Acre)	Total Applied (1,000 pounds)
Carbaryl	3	6.1	0.97	5.87	1.4
Esfenvalerate	6	5.8	0.04	0.21	0.1
Lambda-	81	6.9	0.03	0.19	1.3
cyhalothrin	22	4.00	0.47	1.89	3.4
Methomyl	7	1.1	0.90	1.00	0.5
Turbofos					

[1]Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.
[2]Planted acreage in 2004 was 8,200.

Table 17. Specific insecticide use patterns in New York fresh market sweet corn[1,2]

Active Ingredient	Area Applied (%)	Applications (#)	Rate/Application (Pounds/Acre)	Rate/Crop Year (Pounds/Acre)	Total Applied (1,000 pounds)
Bifenthrin	6	1.9	0.06	0.12	0.2
Carbaryl	2	1.8	1.40	2.46	1.2
Esfenvalerate	6	2.7	0.04	0.11	0.2
Lambda-	55	2.5	0.03	0.07	1.0
cyhalothrin	18	2.5	0.41	1.01	5.2
Methomyl	15	1.9	0.16	0.31	1.3
Permethrin	7	1.3	0.54	0.72	1.5
Thiodicarb					

[1]Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.
[2]Planted acreage in 2004 was 29,000.

Table 18. Specific insecticide use patterns in Pennsylvania fresh market sweet corn[1,2]

Active Ingredient	Area Applied (%)	Applications (#)	Rate/Application (Pound/ Acre)	Rate/Crop Year (Pounds/Acre)	Total Applied (1,000 pounds)
Bifenthrin	1	2.2	0.05	0.11	---[3]
Carbofuran	4	1.0	1.03	1.03	0.8
Chlorpyrifos	9	1.1	0.88	0.98	2.0
Cyfluthrin	5	1.4	0.03	0.04	([2])
Endosulfan	1	2.1	0.45	0.93	0.2
Esfenvalerate	5	1.6	0.04	0.07	0.1
Lambda-cyhalothrin	71	2.7	0.02	0.07	1.0
Methyl parathion	7	4.6	0.53	2.44	3.9
Spinosad	3	1.1	0.06	0.07	---[3]
zeta-Cypermethrin	8	4.5	0.04	0.19	0.3

[1]Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.
[2]Planted acreage in 2004 was 21,800.
[3]Total applied is less than 50 pounds.

Table 19. Specific insecticide use patterns in New York processed sweet corn[1,2]

Active Ingredient	Area Applied (%)	Applications (#)	Rate/Application (Pounds/Acre)	Rate/Crop Year (Pounds/Acre)	Total Applied (1,000 pounds)
Lambda-cyhalothrin	11	1.0	0.02	0.02	---[3]

[1]Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.
[2]Planted acreage in 2004 was 19,500.
[3]Total applied is less than 50 pounds.

Corn Earworm (*Helicoverpa zea*)

Biology and life cycle

Throughout most of the Northeastern region, CEW is an annually invasive pest, invading the region from farther south. In the mid-Atlantic, pupae overwinter in the soil, but they only survive in areas where the frost line is less than an inch below the soil surface. The severity of winter temperatures and the amount of snowfall greatly influence the overwintering range of corn earworm from year to year. Surviving adults (moths) emerge and mate, and females deposit eggs on sweet corn foliage. The early season larvae that hatch from these eggs may feed on the whorls or undeveloped tassels, but this feeding rarely affects corn production or quality.

Adult CEWs are highly mobile, and moth populations migrate northward with moving air masses, especially along the coast. Migrant females lay their eggs singly, preferring fresh corn silks. The larvae hatch in 3 to 5 days, depending upon temperature and move rapidly down the silk channel and into the ear, where they feed on the silks and kernels. Often, damage is only done to within an inch of the tip of the ear. Larvae reach 1.5 inches in length and produce large amounts of frass, which fouls the ear. To kill eggs or newly hatched larvae, insecticide residues must be present at all times on the silk when CEW is laying eggs. Larvae feed and develop for 10 to 21 days and then cut through the husk to exit the ear, drop to the ground, and pupate in the soil. Adults emerge from the pupa in 10 to 25 days.

Distribution and importance

CEW is ranked as the most serious insect pest of sweet corn in the region (2004 New England Sweet Corn Survey, Delaware crop profile). The severity of CEW and FAW infestations may vary from year to year and in different locations within the Northeastern region. Those present at the Sweet Corn PMSP workshop indicated that up to 100 percent of the acres throughout most of New England may have some infestation. Northern and western New York and northwestern Pennsylvania can go years without CEW infestation. In the areas of western New York where there is heavy snow coverage, however, CEW seems to be overwintering. CEW causes economic losses to corn from early July (in more southern and coastal areas) or mid-August (in more northern or inland areas) to late September, in most years. Southern and coastal regions are more severely affected and earworm is a pest in all years; in some northern and inland areas, CEW damage may be insignificant in some years.

Fresh market quality standards are high, and damage or presence of CEW in 1–5 percent of ears makes it unmarketable in wholesale and in most retail markets. In corn grown for processing, CEW may be less of a problem, because in some cases there is a higher tolerance for tip damage than for damage to the side of the ear caused by ECB. Corn grown under contract for processing has allowable damage of 0.25 inch or less in the tip, in 20 percent of the ears.

Nonchemical control

Planting date. Planting as early as possible circumvents CEW problems in areas where CEW normally arrives late in the growing season and would infest corn just before onset of the silk stage (about 21 days before harvest). This is not practical on farms that market sweet corn throughout the season. Early planting also may increase the pressure from seed corn maggot.

Monitoring flight. Monitoring for adult CEW flight, through the use of pheromone or blacklight traps, is a necessary step in the management of this pest. Growers manage traps themselves, hire crop consultants on their own farm, or rely upon regional networks that are generally managed by the state extension program. One or two traps per farm are common. Indications from those present at the Sweet Corn PMSP workshop are that this is an area where professional help, scouts, or increased numbers of extension staff would be helpful for growers to make decisions to reduce pesticide use. The consensus was that trapping and spray timing are critical, that using pheromone traps can reduce the number of sprays, and that support from extension or a professional scout would be helpful. Pheromone traps are not a control measure in and of themselves, but they lead to better control with reduced pesticide input.

Biological control. There is currently no practical, effective biological control of CEW either through native or mass-reared and released beneficial arthropods. Native predators may use eggs as a food source, but they are not sufficient to reduce infestations. Mass-reared beneficials that are available for suppression of CEW (such as *Trichogramma pretiosum*) have not proven effective for economic levels of control. For use of biological control, there was concern that a better infrastructure is needed for supplying a product and information on its use.

Microbial insecticides. Some members of the PMSP group rated spinosad (Entrust) as the best control measure available to organic growers, whereas others suggested that vegetable oil application on the silks (Zea-later) is effective, but only for small-scale growers. Dipel or Xentari also is available to organic growers, but for use against CEW they are more effective when used in direct silk application with vegetable oil than as a silk spray.

Chemical control (Tables 20–22)

IPM systems use moth flight activity, assessed by pheromone or blacklight traps, to determine the need for and timing of insecticide applications. In the absence of trap data, growers rely on crop stage, time of year, and past experience. Continuous coverage of silk is critical if adults are being caught in pheromone traps. Trap counts correlate with the number of eggs being laid and subsequent infestations of the ear. Repeat applications are made to the silk every 3 to 6 days, depending on trap captures and temperature (above 85°F, a shorter interval is used). If weather conditions remain warm and favorable for CEW development, treatments are continued until silk is completely dry and brown, or up to 5 days before final harvest. Microbial insecticides such as Bt and spinosad are labeled for this pest. Bt may cause suppression but is inadequate for economic control, because it must be ingested for toxicity to the insect and larvae feed very little before entering the ear. Spinosad has demonstrated effectiveness at moderate pest levels, but it is 3 to 4 times more expensive than currently used materials.

Some research indicates the effectiveness of corn or soybean oil and Bt mix as an alternative to chemical control. A small quantity of oil is applied directly to each silk by using a hand-held applicator; hence, this method is most appropriate to smaller scale operations. To enhance the farm-scale adoption of this method, a hand-held gun-style applicator, called a Zea-later, was developed by the University of Massachusetts and is available commercially. An example of materials used in this method would be soybean oil (Stroller Golden Pest Spray Oil): 0.5 milliliters is applied by hand directly to silk between 5 and 7 days after 50 percent of the ears are silking (reentry interval [REI] 12 hours) mixed with Bt (e.g., Dipel DF, Group 11, applied at 0.5 pounds per acre). To prevent problems related to phytotoxicity, foliar applications of oil should be avoided. Mixing Bt with the oil improves control. Applications are limited to one application per ear; 5 percent of growers in New England are using this method (2004 New England Sweet Corn Survey).

Table 20. Chemicals registered for treatment of corn earworm

Trade Name	Common Name	Rate	REI (h)	DH
XenTari	*Bacillus thuringiensis aizawai*	1/2–2 pounds/acre	4	0
	Bacillus thuringiensis kurstaki		4	0
Capture* 2EC	Bifenthrin	2.1–6.4 oz/acre	12	1
Baythroid* 2	Cyfluthrin	1.6–2.8 oz/acre	12	0
Decis* 1.5EC	Deltamethrin	1.5–2.4 oz/acre	12	1
Asana* XL	Esfenvalerate	5.8–9.6 oz/acre	12	1
Proaxis*	gamma-Cyhalothrin	2.5–3.8 oz/acre	24	1
Warrior	lambda-Cyhalothrin	2.5–3.8 oz/acre	24	1
Lannate SP*	Methomyl	1/4–1/2 pound/acre	48	0 for ears, 3 if used for feed or forage
Ambush*	Permethrin	6.4–12.8 oz/acre	12	1
Stroller Golden Pest Spray Oil	Soybean oil	0.5 ml within 7 days of 50% of corn are in silk	12	
Entrust	Spinosad	1–2 dry oz/acre	4	1
SpinTor 2SC	Spinosad	3–6 oz/acre	4	1
Larvin* 3.2	Thiodicarb	20–30 oz/acre	48	0
Mustang*	zeta-Cypermethrin	3–4.3 oz/acre	12	3

*Indicates restricted use insecticide.

Additional comments regarding specific chemical control

B. t. aizawai (XenTari). Use alone to control light-to-moderate populations; add a contact insecticide to control moderate-to-heavy populations. Organic Materials Research Institute (OMRI) listed.

B. t. kurstaki. Can be tank mixed with other insecticides. Follow manufacturer's directions. Many products approved for organic use.

Bifenthrin (Capture 2EC)*. Use prohibited on corn in all coastal counties. Methomyl (Lannate SP*): Some corn varieties may be damaged by methomyl. More severe damage may occur with the Lannate* LV formulation than with the Lannate* SP (soluble powder) formulation. May not provide effective control under high CEW pressure.

Soybean oil (Stroller Golden Pest Spray Oil). Apply 0.5 milliliter by hand directly to silk within 7 days after 50 percent of the ears are silking (REI 12 h, Group 25). Caution: avoid foliar application to prevent phytotoxicity. Apply at least 4 to 5 days after silk initiation to avoid tip injury and before 6 to 7 days after silk initiation to gain optimum control. Mix with Bt (i.e., XenTari, Dipel ES) for improved control. One application per field. Commercial oil applicators (i.e., Zea-later) are available.

Spinosad (Entrust). Do not feed ears/stalks to animals for 28 days. Effective for low CEW pressure. Switch to another product when CEW pressure is high (13 or more moths/night in pheromone trap) or when a 3-day spray schedule is warranted. OMRI listed.

Spinosad (SpinTor 2SC). Effective for low CEW pressure. Switch to another product when CEW pressure is high (13 or more moths/night in pheromone trap) or when a 3-day spray schedule is warranted.

Thiodicarb (Larvin 3.2)*. DO NOT feed silage to livestock.

Table 21 reports information provided by 210 New England sweet corn growers regarding their management of corn earworm and the use of chemical control. Of these 210 growers, 27 (15 percent) indicated that they used no chemical control. The 3,617 acres treated by the 183 growers that used some type of chemical pest control for corn earworm, represent treatment of 81 percent of the sweet corn acreage. This table also shows how those who used each individual chemical would rate the efficacy of the chemical from excellent to poor.

Table 21. Use patterns of New England growers for non-chemical and chemical control of corn earworm

Nonchemical	**# Growers**	**% Growers**	**# Acres**	% Acres	**Excellent**	**Good**	**Poor**
Golden Natural Spray Oil	3	1	26	1	1	1	1
Generic soybean oil	1	<1	0.6	<1	0	0	0
Bullseye	1	<1	0.6	<1	0	0	0
Handpick	1	<1	0.1	<1	1	0	0
Crop rotation	1	<1	1	<1	0	1	0
Lady bugs	1	<1	2	<1	0	0	0
Pesticide							
Warrior	103	48	2689	60	75	25	1
Lannate SP	82	38	2156	48	48	30	2
Larvin 3.2	36	17	707	16	20	12	4
Asana XL	19	9	632	14	9	10	0
Ambush	27	13	462	10	8	16	3
Baythroid 2Spintor 2SC	8	4	316	7	3	5	0
Sevin	7	3	192	4	4	2	1
Dipel DF or ES	11	5	78	2	2	6	2
Pounce	8	4	56	1	2	4	2
Entrust	3	1	46	1	2	1	0
Permethrin	7	3	23	1	4	2	1
Pheromone traps	1	<1	20	<1	1	0	0
Zealater with DiPel	1	<1	15	<1	1	0	0
Lannate	2	1	5	<1	2	0	0
Capture 2EC	1	<1	4	<1	1	0	0

Table 21 (continued). Use patterns of New England growers for non-chemical and chemical control of corn earworm

Pesticide	# Growers	% Growers	# Acres	% Acres	Excellent	Good	Poor
Thuricide	1	<1	1.5	<1	0	1	0
Pyronyl	1	<1	0.6	<1	0	0	0
Mustang MAX	1	<1	0.5	<1	0	1	0
XenTari	0						

Table 22. Chemical control efficacy for corn earworm as rated by participants at the Sweet Corn PMSP workshop

Pesticide	Workshop Participants	% Workshop Participants	E	E–G	G	F–G	F	F–P	P
Warrior	9	64	5	0	3	0	0	0	1
Larvin 3.2	3	21	1	0	2	0	0	0	0
Asana XL	3	21	0	0	0	2	1	0	0
Ambush	5	36	0	0	0	1	4	0	0
Baythroid 2	6	43	4	0	1	0	1	0	0
Spintor 2SC	5	36	0	0	2	1	0	2	0
Sevin	5	36	0	0	0	0	5	0	0
Dipel DF or ES	2	14	0	0	1	0	0	0	1
Pounce	5	36	0	0	0	1	4	0	0
Golden Natural Spray Oil	1	7	0	0	1	0	0	0	0
Entrust	4	29	0	0	2	1	1	0	0
Lannate	6	43	2	1	3	0	0	0	0
Capture 2EC	4	29	3	1	0	0	0	0	0
Mustang MAX	4	29	0	3	1	0	0	0	0

Additional comments of workshop participants regarding specific chemical controls for CEW

Entrust. The best control method available to organic growers.

Dipel. Dipel and now XenTari are also available for organic production.

Pyrethroids. Not as effective under high temperatures, and there was some concern expressed that resistance is building coming from the south.

Lannate. Control is inconsistent for some growers under high pressure.

Larvin. Indications were that it is not readily available.

Sevin. Some concern was expressed regarding applicator exposure and effect on beneficials.

Spintor. Efficacy of control depends upon pressure.

Warrior. Causes skin reaction in some people.

European corn borer (*Ostrinia nubilalis*)

Biology and life cycle

ECB is an introduced pest that is established throughout the Northeastern region. ECB overwinters as fully grown larvae in the stems and ears of corn plants, usually just above ground level, and these larvae complete their development in the spring. Adults emerge according to temperature, and phenology models based on temperature can be used to predict emergence and first egg laying. Females of the first generation lay their eggs on the underside of corn leaves from mid-May to late June, depending on location. Eggs hatch in 3 to 7 days, depending upon temperature. During the whorl stage, the emerging larvae feed on leaves within the inner whorl; at pretassel stage, they feed on succulent tassel; and after tassels emerge and dry out, during the silk stage, they move into the stalk or tunnel into the ear. This stage is when ECB becomes the most serious as pest problem because the larvae are difficult to control. Generally, females will lay eggs on the ear. Newly hatched larvae move to the silk within a few hours and then inside the ear where they cannot be controlled. Thus, control methods are targeted at the pretassel stage. Larvae enter the ear via the silks or from the shanks or side by burrowing through plant tissues. They feed on all plant tissue, boring through the husk and kernels into the corn cob, causing damage to the ear and reducing marketable yields. Damage to the side or tip renders the ear unmarketable; side damage is particularly serious in processing corn because it cannot be removed during processing.

Except in northern New England, a second generation of the pest occurs and causes more serious damage because more sweet corn fields are producing ears at this time, and pest numbers may be higher. In certain areas, most notably New York state, a univoltine strain is active in midseason, between generations of the bivoltine strain, resulting in continuous pressure from ECB throughout the season. In southern areas, a partial third generation may occur.

Two strains or races of ECB exist in the region, often co-occurring in varying proportions of the population. They are primarily distinguished by the pheromone chemistry. The E or New York strain and Z or Iowa strain are monitored by different pheromone blends placed in separate traps.

Distribution and importance

ECB is a serious pest of sweet corn, ranked equal to CEW in frequency of occurrence and losses. The relative severity of the two pests varies within the region, but ECB occurs throughout the Northeastern region. Eighty to 100 percent of acreage is affected by this pest. In fresh market sweet corn, it is easier to cull ECB-infested ears compared with corn earworm, because husk damage is obvious. In processing corn, ECB damage is cause for rejection because damage and larvae cannot be removed in processing.

Nonchemical control

Use of resistant varieties, adjusting planting dates, field sanitation, floating row cover, and biological control are all potential management options for ECB.

Field sanitation. Destroying overwintering sites requires that all crop residues that may harbor overwintering corn borers be completely destroyed and removed before emergence. For the most effective control, stalks also should be well shredded before disking or plowing.[1] Effective weed control also contributes to reduced ECB infestations; poor weed control is associated with increased oviposition.

Biological control. Release of parasitic *Trichogramma* wasps, particularly *T. ostriniae,* into sweet corn has been documented to have significant impact on infestations given proper timing and release rates. Optimal timing for placement of cards with wasp eggs attached is in the mid-whorl stage (12–18 inches in height) when ECB flight is rising or at peak. Two or three releases may be needed to achieve control, at release rates ranging from 30,000 to 60,000 wasps per acre. After wasps emerge, they parasitize ECB eggs. Wasps multiply during the season and travel at least 0.25 mile into adjacent blocks. Research shows parasitism rates ranging from 60 to 97 percent by using *T. ostriniae*, an Asian *Trichogramma* species that was introduced into the United States in 1990. A major barrier to more widespread use has been the lack of a commercial domestic source of mass-reared wasps.[4] Other species of Trichogramma (*T. pretiosum* and *T. brassicae*) are commercially available but have lower efficacy against ECB in corn. Native predators that attack eggs or larvae include the twelvespotted ladybeetle, *Coleomegilla maculata.* Conservation of this species and other beneficials by use of reduced-risk insecticides can help suppress ECB.

Floating row cover. Floating row cover is used by some growers to accelerate growth and to provide a barrier to oviposition by ECB adults. Covers are generally removed before tasseling, but growers save one or more sprays because egg laying is delayed until after cover is removed. Wide covers are used for ease of handling, on 12–20 row blocks. This method is more cost effective when covers are rolled and stored for multiple use.

Planting dates. Where ECB has two generations, planting dates that reach susceptible stage between generations can reduce severity. Earliest and latest corn is most severely affected.

Chemical control (Tables 23–25)

Thresholds used for control of ECB are generally based upon field scouting for eggs or larvae or upon moth flight activity, as indicated by pheromone or blacklight traps. Thresholds vary somewhat throughout the region; however, a widely used threshold in New England, New York, and the mid-Atlantic is to initiate insecticide treatments at the pretassel stage (when the tip of the developing tassels can be seen emerging from the whorls) if 15 percent or more of the plants show larval feeding or presence of ECB. The pretassel stage is the optimal time to achieve ECB control because larvae are more exposed as tassels emerge than when buried in the whorl. Earlier treatments are of little value. Subsequent sprays are recommended 3–5 days later if the threshold is still exceeded. Once a field is silking, the threshold drops to 5 percent infested plants based upon scout the ear zone (roughly from two leaves above and one leaf below the ears) for ECB egg masses and ECB or FAW larvae (New York state). Alternatively, sprays are based upon trap captures, with weekly sprays recommended if flight exceeds seven moths per week.

Corn that is started under clear plastic matures sooner in the year, in which case developing ears may be present during the first flight of ECB. Because of this synchrony between developing ears and ECB egg laying, corn grown under plastic can be heavily infested by this pest. If plants are in silk and adult moths are active, developing ears need protection. This situation occurs in New England (not sure about farther south).

No sprays are needed within 7 to 10 days before harvest.

Because of overlapping occurrence of corn earworm, European corn borer, and fall armyworm, a single insecticide application may target two or more of these pests.

B. t. variety *kurstaki* is a microbial pesticide that is effective in controlling ECB. Ingestion before the larvae bore into the plant is the only way this control can be effective. Monitoring plays an important part in this type of control. As with other materials, sprays should be applied just before or after tasseling and before the larvae bore into the ear or the stalk.[2] Because it is slower acting there may be justification for treatment at an infestation level of 10 percent or more.

Table 23. Chemicals registered for treatment of European corn borer

Trade Name	Common Name	Rate	REI (hours)	Days to Harvest
XenTari	*Bacillus thuringiensis aizawai*	Manufacturer's recommended rates	4	0
	Bacillus thuringiensis kurstaki	Manufacturer's recommended rates	4	0
Capture* 2EC	Bifenthrin	2.1–6.4 ounces/acre	12	1
Baythroid* 2	Cyfluthrin	1.6–2.8 ounces/acre	12	0
Decis* 1.5EC	Deltamethrin	1.5–2.4 ounces/acre	12	1
Asana* XL	Esfenvalerate	5.8–9.6 ounces/acre	12	1
Proaxis*	gamma-Cyhalothrin	2.5–3.8 ounces/acre	24	1
Avaunt	Indoxacarb	2.5–3.5 ounces	12 for mechanically harvested and 14 days for hand harvested	3
Warrior	lambda-Cyhalothrin	2.5–3.8 ounces/acre	24	1
Lannate SP*	Methomyl	1/4–1/2 pounds/acre	48	0 for ears, 3 if used for feed or forage
Intrepid 2F	Methoxyfenozide	4–8 ounces/acre	4	3
Ambush*	Permethrin	6.4–12.8 ounces/acre	12	1
Entrust	Spinosad	0.5–2 dry ounces/acre	4	1
SpinTor 2SC	Spinosad	1.5–6 ounces/acre	4	1
Larvin* 3.2	Thiodicarb	20–30 ounces/acre	48	0

Additional comments regarding specific chemical controls

B. t. kurstaki: Manufacturers' directions dictate rates. Good coverage is essential and can be increased by the use a spreader sticker. Shorter spray intervals (4–5 days) and high rates should be used under high ECB pressure.

Bifenthrin (Capture 2EC)*. Use prohibited on corn in all coastal counties.

Indoxacarb (Avaunt). Whorl through tassel emergence (before silking) application only.

Methomyl (Lannate SP)*. Phytotoxicity may occur on some varieties. More severe damage may occur with the Lannate* LV formulation than with the Lannate* SP (soluble powder) formulation.

Methoxyfenozide (Intrepid 2F). Insect growth regulator. Stops larval feeding within hours but takes several days to cause mortality.

Spinosad (Entrust): Ears or stalks should not be fed to animals for 28 days. Meets USDA National Organic Standards.

Thiodicarb (Larvin 3.2)*. Silage of treated crops must not be fed to livestock.

Table 24 reports information provided by 213 New England sweet corn growers regarding their management of corn earworm and the use of chemical control. Of these 213 growers, 27 (15 percent) indicated that they used no chemical control. The 3,459 acres treated by the 183 growers that used some type of chemical pest control for CEW represent 77 percent of the sweet corn acreage. This table also shows how those who used each individual chemical would rate the efficacy of the chemical from excellent to poor.

Comments of workshop participants regarding specific nonchemical and chemical control methods for ECB are provided in Table 25.

Table 24. Use patterns of New England growers for control of European corn borer

Nonchemical	**# Growers**	**% Growers**	**# Acres**	**% Acres**	**Excellent**	**Good**	**Poor**
Rotation	1	<1	22	1	0	1	0
Ladybugs	1	<1	2	<1	0	0	1
Pesticide							
Warrior	95	44	2284	51	71	23	1
Lannate SP	87	40	2177	49	52	33	2
Larvin 3.2	39	18	829	19	21	15	3
Ambush	35	16	660	15	13	19	3
Asana XL	19	9	563	13	9	9	1

Table 24 (continued) . Use patterns of New England growers for control of European corn borer

Pesticide	# Growers	% Growers	# Acres	% Acres	Excellent	Good	Poor
Spintor 2SC	18	8	456	10	12	5	1
Baythroid 2	11	5	416	9	5	5	1
Mustang MAX	1	<1	153	3	0	0	0
Dipel DF or ES	16	7	131	3	5	8	1
Sevin	10	5	109	2	3	5	2
Pounce	7	3	72	2	4	3	0
Lorsban	1	<1	65	1	1	0	0
Intrepid 2F	2	1	23	1	1	0	1
Entrust	6	3	22	1	4	2	6
Permethrin	1	<1	20	<1	1	0	0
Xentari	1	<1	4.5	<1	1	0	0
Lannate	1	<1	4	<1	1	0	0
Capture 2EC	1	<1	1.5	<1	0	1	0
Thuricide (Bt Kurstaki)	1	<1	0.6	<1	0	0	0
Avaunt	0						

Table 25. Chemical control efficacy for European corn borer as rated by participants at the Sweet Corn PMSP workshop

Pesticide	Workshop Participants	% Workshop Participants	E	E–G	G	F–G	F	F–P	P
Warrior	7		3	1	3	0	0	0	0
Asana XL	3	21	0	0	1	0	2	0	0
Ambush	5	36	0	0	4	0	1	0	0
Avaunt	4	29	0	0	2	2	0	0	0
Baythroid 2	6	43	3	1	0	0	1	0	0
Capture	4	29	3	1	0	0	0	0	0
Spintor 2SC	4	29	1	1	0	2	0	0	0
Diazinon	2	14	1	0	0	1	0	0	0
Dipel DF or ES	3	21	1	0	1	0	1	0	0
Intrepid	2	14	0	0	0	0	1	1	0
Pounce	5	36	0	0	4	0	1	0	0
Entrust	3	21	0	0	2	0	1	0	0
Lannate	5	36	3	1	0	0	1	0	0
Larvin	6	43	1	0	4	0	1	0	0
Mustang MAX	2	14	0	0	2	0	0	0	0

Fall Armyworm (*Spodoptera frugiperda*) **and Armyworm** (*Leucania convecta*)

FAW does not generally overwinter in the Northeastern region. Infestations result from fertile females migrating northward on storm fronts from southern states. Adult females lay egg masses of 50 or more on the underside of leaves, preferring whorl-stage corn. Eggs hatch in 10 days depending on temperature. Larvae feed gregariously in the whorl when they are young and disperse as they grow. Plant growth and yield may be reduced if there is extensive feeding during the early whorl stage. As corn develops, larvae move into green tassels, and, if larvae are not fully grown by the silk stage, they may enter ears through the silk tube or the side of the ear and feed on the kernels. At this stage, damage to the ear is severe. Control methods are timed to kill larvae before the silk stage. When fully grown, larvae move into the soil and pupate for 10–14 days. A second generation is not important in northern parts of the Northeastern region, but it may be significant in southern areas.

Distribution and importance

FAW is a sporadic but important pest of sweet corn. It ranks third in importance, after CEW and ECB. Acreage affected ranges from 0 to 80 percent depending on the year, time in the season, and location within the region. Those growers present at the Sweet Corn PMSP workshop felt that the incidence of this pest was generally low in New England, except along the southern coast, and in New York state, and higher in the mid-Atlantic states. They also felt that pest pressure depends on summer storms, which influence the migratory behavior of the insect, and that pest pressure may be affected by rotation and field size. There was the opinion that the pest pressure was not so serious on smaller fields surrounded by different crops.

In New England, 37 percent of acres are treated for FAW. Migration into the southern parts of the Northeastern region usually begins in late June, moves northward, and typically reaches New England in late July or August. Numbers are usually highest along coastal areas and later in the season. In inland and northern areas, significant infestations are rare.

Nonchemical control

Few nonchemical control measures exist for this pest. Early plantings avoid FAW; however, because growers need succession harvest all season, this approach is not viable for most acreage. Transgenic cultivars are available, but they are not very effective for control of this pest. Monitoring through field scouting is critical. Use of pheromone traps is important, and the type of pheromone used is critical. However, some growers at the Sweet Corn PMSP workshop expressed concern that, in New York state, traps are unreliable with pheromones.

Chemical control (Tables 26–28)

Thresholds for this pest depend upon pheromone or blacklight traps to detect adult flight and field scouting to determine the percentage of plants with egg masses, live larvae, or fresh feeding damage. There are variations in thresholds within the Northeastern region. Traps are especially useful because of the sporadic and unpredictable nature of FAW arrival and numbers. However, actual field scouting is crucial in decision making and timing of sprays. Whorl, pretassel, green tassel, or silk stage may be treated, but thresholds differ for growth stages.

Microbial insecticides (Bt, spinosad) are registered for FAW but are not widely used.

Table 26. Basic chemical control information for armyworm

Trade Name	Common Name	Rate	REI (hours)	Days to Harvest (dh)
Asana* XL	Esfenvalerate	5.8–9.6 ounces/acre	12	1
Ambush	Permethrin	6.4–12.8 ounces/acre	12	1
Avaunt	Indoxacarb	2.5–3.5 ounces/acre	REI 12 h for mechanically harvested and 14 d for hand harvested	3
Baythroid* 2	Cyfluthrin	2.8 ounces/acre	12	0
Capture* 2EC	Bifenthrin	2.1–6.4 ounces/acre	12	1
Decis* 1.5EC	Deltamethrin	1.5–2.4 ounces/acre	12	1
Entrust	Spinosad	0.5–2 dry ounces/acre	4	1
Lannate SP	Methomyl	0.25–0.5 pounds/acre	48	0 dh for ears, 3 dh if used for feed or forage
Larvin* 3.2	Thiodicarb	20–30 ounces/acre	48	0
Proaxis	gamma-Cyhalothrin	2.5–3.8 ounces/acre	24	1
SpinTor 2SC	Spinosad	1.5–6 ounces/acre	4	1
XenTari	*B. thuringiensis aizawai*	0.5–2 pounds/acre	4	0
Warrior	lambda-Cyhalothrin	2.5–3.8 ounces/acre	24	1

Additional comments regarding specific chemical controls

Avaunt. Whorl through tassel emergence (before silking) application only.

Baythroid 2*. For FAW first and second instars only.

Capture 2EC*. Use prohibited on corn in all coastal counties.

Entrust. Do not feed ears/stalks to animals for 28 day. OMRI listed

Proaxis. For control of first and second instars only.

Lannate SP. Some sweet corn varieties may be damaged by methomyl. More severe damage may occur with the Lannate* LV formulation than with the Lannate* SP (soluble powder) formulation.

Larvin 3.2*. DO NOT feed silage to livestock.

SpinTor 2SC. Conserves aphid predators if it is the only spray, which would be a poor management practice unless applied early in the whorl. This product also has as more impact on beneficials than Bt.

Warrior. Use high rate for large larvae.

XenTari. Use alone to control light populations of first and second instars. Add a contact insecticide to control more mature larvae and higher populations. Follow manufacturer's directions. OMRI listed.

Table 27 reports information provided by 210 New England sweet corn growers regarding their management of FAW and the use of chemical control. Of these 210 growers, 82 (40 percent) indicated that they used no chemical control. The 1,673 acres treated by the 128 growers that used some type of chemical pest control for corn earworm, represents 37 percent of the sweet corn acreage. This table also shows how those who used each individual chemical would rate the efficacy of the chemical from excellent to poor.

Table 27. Use patterns of New England growers for control of fall armyworm

Pesticide	# Growers	% Growers	# Acres	% Acres	Excellent	Good	Poor
Warrior	73	34	1118	25	48	22	3
Lannate SP	62	29	908	20	35	23	4
Larvin 3.2	26	12	223	5	9	16	1
Asana XL	13	6	191	4	4	8	1
Baythroid 2	8	4	179	4	3	4	0
Ambush	19	9	150	3	8	10	0
Mustang	1	<1	68	2	0	0	0
Spintor 2SC	5	2	38	1	4	1	0
Pounce	2	1	38	1	1	1	0
Dipel DF or ES	4	2	20	<1	1	2	1
Permethrin	1	<1	15	<1	1	0	0

Table 27. Use patterns of New England growers for control of fall armyworm

Pesticide	# Growers	% Growers	# Acres	% Acres	Excellent	Good	Poor
Sevin	3	1	6	<1	0	2	0
Capture 2EC	1	<1	1.5	<1	0	1	0
Entrust	0						
XenTari	0						

Comments of workshop participants regarding specific chemical control methods for FAW are provided in Table 28.

Table 28. Chemical control efficacy for FAW as rated by those who attended the Sweet Corn PMSP workshop

Pesticide	Workshop Participants	% Workshop Participants	E	E –G	G	F–G	F	F–P	P
Warrior	9	64	3	0	2	0	1	0	0
Larvin 3.2	2	18	0	1	1	0	0	0	0
Asana XL	3	21	0	0	0	0	0	0	3
Ambush	4	29	0	0	0	0	1	0	3
Avaunt	3	21	3	0	0	0	0	0	0
Baythroid 2	5	36	1	0	1	0	3	0	0
Spintor 2SC	1	14	0	0	1	0	0	0	0
Dipel DF or ES	3	21	0	0	1	0	2	0	0
Pounce	4	29	0	0	0	0	1	0	3
Entrust	3	21	0	0	2	0	1	0	0
Lannate	6	43	1	2	3	0	0	0	0
Capture 2EC	3	21	0	0	1	0	2	0	0
Mustang MAX	2	18	0	0	0	0	2	0	0

Additional comments of workshop participants regarding specific chemical control methods for FAW

Avaunt. Works great but too expensive, and it is necessary to buy large quantities.

Lannate or Warrior. Choice of most growers. However, Warrior control is dependent on pest pressure, and the opinion was that it provides inadequate control under high pest pressure.

Corn Leaf Aphid (*Rhopalosiphum maidis*)

Corn leaf aphids do not survive the winter where winters are severe; they may overwinter in the southern part of the Northeastern region as eggs or females on small grains. Where they do not overwinter, they reinvade annually from further south. Populations consist of winged and wingless females. Because wingless females reproduce through many generations without mating and give birth to live nymphs, populations can increase rapidly. Up to 40 generations may occur in 1 year.

Corn plants become a good host at about 30 days, and the succulent tassel forming inside the whorl is particularly suitable for aphids. As tassels emerge, aphids may build up to large colonies on the tassel and disperse elsewhere on the plant, including to the silks and husks. Plant damage occurs only from large colonies and may include interference with pollination, necrosis of upper leaves, or delay in maturity. The most common problem is from excretion of a sugary, sticky substance called honeydew. When large colonies of aphids are present on tassels, honeydew coats leaves, tassels, and ears and promotes the growth of black sooty mold. Aphids also may burrow between leaves of the husk. These conditions detract from the appearance of the corn and can be a serious problem for fresh market sweet corn[3]

Corn leaf aphid is a poor vector of *Maize dwarf mosaic virus* (MDMV). Control of corn leaf aphid has little or no impact on the spread of this corn pathogen.

Pest distribution and importance

Surprisingly, members of the PMSP group reported corn aphid to be more of a problem in the New England states than in mid-Atlantic states. Outbreaks may occur throughout the region, but they do not occur in every crop or every year. Those that do occur are generally in late July to August. The PMSP group reported that in Delaware they are seen but generally not economically damaging, whereas in Vermont and Massachusetts their cosmetic damage can make fresh market corn unmarketable. Conditions that favor this pest include dry soil conditions and moisture stress in the crop, high temperatures, excessive levels of soil nitrogen, and absence of endemic natural enemies. Use of broad-spectrum insecticides such as synthetic pyrethroids for caterpillars control induce aphid outbreaks by killing natural enemies. A combination of low nitrogen and high presence of beneficial insects decreases outbreaks of this pest.

Nonchemical control

Field monitoring (e.g., checking five plants at each of five locations in the field) is done at pretassel or tassel stage to determine presence of large or increasing numbers of aphids in the developing tassel. Treatments are based on percentage of tassels with large numbers of aphids (e.g., 25 percent of plants), absence of natural enemies, and moisture stress. Treatments at pretassel or green tassel stage are most effective. Scouting is most critical under drought conditions. Seed corn producers must pay special attention to protect pollen availability from inbred lines.

Natural enemies of aphids are usually abundant in corn, and they prevent aphids from reaching outbreak proportions. Predators include numerous species of ladybird beetles, minute pirate bugs (*Orius* spp.), lacewing larvae, and predatory midges; several parasitoids (e.g., wasps that lay eggs in the aphid nymphs, where hatching larvae develop and ultimately kill the host) are also common. Conserving predators and parasites in corn by using selective insecticides or biological organisms to control caterpillars, especially early in the season when ECB is the dominant pest, is an important strategy for reducing aphid outbreaks.

Chemical control (Tables 29 and 30)

Comments from the PMSP group. When an outbreak occurs, Lannate is often the product of choice and is considered the most effective product available. Warrior suppresses aphids, but it does not provide significant control. However, use of pyrethroids for worm control also may induce aphid outbreaks. Thionex 50W works well, but it is "stinky for the neighbors" and may only be used for fresh market corn, not processing corn.

Where spinosad (Spintor and Entrust) or Bt products are used for caterpillar pests, beneficials that suppress aphids are conserved. However, these products do not directly control aphids. Insecticidal soap is a "soft" alternative for aphids, but it does not give not reliable control.

Table 29 reports information provided by 209 New England sweet corn growers regarding their management of corn leaf aphid and the use of chemical control. Of those 209 growers, 147 (71 percent) indicated that they used no chemical control for this pest. The 1,313 acres treated by the 62 growers that used some type of chemical pest control for corn leaf aphid represents 20 percent of the sweet corn acreage. This table also shows how those who used each individual chemical would rate the efficacy of the chemical from excellent to poor.

Table 29. Use patterns of New England growers for control of corn leaf aphid

Pesticide	# Growers	% Growers	# Acres	% Acres	Excellent	Good	Poor
Lannate SP	43	20	897	20	29	12	1
Warrior	30	14	586	13	11	13	5
M-Pede	1		170	4	0	0	0
Thionex 50W	2	1	16	<1	2	0	0
Lannate	1		9	<1	0	1	0
Capture 2EC	0						

Comments of workshop participants regarding specific chemical control methods for corn leaf aphid are provided in Table 30.

Table 30. Chemical control efficacy for corn leaf aphid as rated by participants at the Sweet Corn PMSP workshop

Pesticide	Workshop Participants	% Workshop Participants	E	E –G	G	F–G	F	F–P	P
Asana	1		0	0	0	0	1	0	0
Baythroid	1		0	0	0	0	0	0	1
Thionex 50W	1		0	0	1	0	0	0	0
Metasystox R	1		1	0	0	0	0	0	0
Lannate	2		1	0	1	0	0	0	0
Gaucho	1		0	0	0	0	0	0	1
Warrior	2		0	0	0	0	1	0	1

Corn Flea Beetles (*Chaetocnema publicaria*)

These beetles overwinter as adults in soil and debris of grassy areas near corn. Corn as well as many cultivated and wild grasses and sedges are hosts. Direct injury is caused by adults feeding on leaves of seedlings, which causes whitened feeding streaks but rarely causes significant damage. More important is the transmission of the bacterium *Erwinia stewartii*, which causes Stewart's wilt disease. The bacterium survives in the gut of the adult beetle and enters the plant through feeding wounds. The survival of beetles and subsequent infections of spring plantings are higher after mild winters and after a previous season with high incidence of Stewart's wilt. Beetles also become infected by feeding on infected hosts, and they subsequently transmit the bacterium when they feed on other plants. The proportion of the overwintered population that is infected with the bacterium is variable and has been reported at 20–40 percent. Infection rates may increase to 80 percent later in the season.

A winter temperature index ("flea beetle index") is used as a predictor of Stewart's wilt severity. The average air temperatures (in degrees Fahrenheit) for December, January, and February are totaled, and if the total is greater than 100, Stewart's wilt is expected to be destructive in the following year. If the 3-month average is below 90, the risk is relatively small due to dead beetles. If it is between 90 and 100, risk is intermediate. The size of flea beetle populations late in the season is important in determining the size of the population that enters overwintering and subsequently may vector Stewart's wilt the following spring.

Overwintered adults lay eggs at the base of corn plants, and larvae and pupae develop underground. A new generation of adults emerges after about 30 days. Two, three, or more generations may occur each year depending on location. Larval feeding is not considered to cause economic damage.

Distribution and importance

Those present at the Sweet Corn PMSP workshop felt that occurrence of this pest seems to be cyclical. Northern distribution was previously considered to be New York state and Massachusetts, but the range is moving northward as a result of warmer winters. Growers felt this was particularly true in New England and New York state, especially in fields that are planted early in New York. Damage is most severe when corn is young, <6 inches in height, and when growing conditions (e.g., cold and wet springs) stress developing seedlings.

Nonchemical control

Susceptibility to Stewart's wilt varies among sweet corn cultivars. Some varieties are more tolerant to the pathogen and do not show symptoms, even when the pathogen is present. The New England Vegetable Management Guide in the region usually rate varieties for tolerance to Stewart's wilt, and seed catalogs also provide this information. Insecticide treatments may only be needed on varieties with low tolerance to Stewart's wilt (see Sweet Corn Varieties section on page 75).

Monitoring is conducted by searching for beetles on leaves when corn is at the spike to seedling (<6 leaf-leaf stage) stage to determine the percentage of plants infested with beetles. Thresholds within the region vary: the Northeast Sweet Corn Production and IPM Manual recommends treatment if 5 percent or more of plants are infested with flea beetles in a susceptible variety. Another resource (Capinera 2001; New York State Guide for Vegetables, 2005) recommends a threshold of six beetles per 100 plants, on susceptible varieties, up to the mid-whorl stage.

Spunbonded row covers, which are used for growth enhancement in early corn, can protect plants against corn flea beetle.

Chemical control (Tables 31 and 32)

Pennsylvania, New York, New Jersey, Maryland, and Delaware use seed and in furrow treatments on early planted, nontolerant cultivars. These treatments are less effective under cold, wet conditions. For foliar applications, pyrethroids are the preferred rescue treatment. Growers scout and apply rescue treatments corn flea beetle numbers reach the economic threshold.

Table 31 reports information provided by 209 New England sweet corn growers regarding their management of corn flea beetles and the use of chemical control. Of those 209 growers, 185 (89 percent) indicated that they used no chemical control. The 468 acres treated by the 24 growers that used some type of chemical pest control for corn leaf aphids represent treatment of 10 percent the sweet corn acreage. This table also shows how those who used a particular chemical would rate the efficacy of the chemical from excellent to poor.

Table 31. Use patterns of New England growers for control of corn flea beetles

Pesticide	# Growers	% Growers	# Acres	% Acres	Excellent	Good	Poor
Lannate SP	13	6	356	8	5	7	0
Warrior	9	4	62	1	6	2	0
Thimet 20G	1	<1	36	1	0	1	0
Ambush	1	<1	30	1	0	1	0
Gaucho 600	3	1	29	1	2	1	0
Cruiser 5FS	2	1	28	1	1	1	0
Sevin XLR Plus	3	1	21	<1	2	1	0
Asana XL	0						
Baythroid 2	0						
Capture 2EC	0						
Counter 15G	0						
Mustang MAX	0						

Comments of workshop participants regarding specific chemical control methods for corn flea beetles are provided in Table 32.

Table 32. Chemical control efficacy for corn flea beetles as rated by participants at the Sweet Corn PMSP workshop

Pesticide	Workshop Participants	% Workshop Participants	E	E–G	G	F–G	F	F–P	P
Warrior	1	7	1						
Gaucho, 1(seed)	2	14	1		1				
Furadan, 1(seed)	2	14	1						
Counter 1G, 2E	3	21	2		1				
Cruiser 1(seed)	2	14	1						
Ambush	3	21	3						
Asana	1	7	1						
Pounce	3	21	3						

Seedcorn Maggot (*Delia platura*)

Seedcorn maggots overwinter as pupae in the soil and emerge as adults in the spring. Soils that are high in decaying manure or vegetable matter, especially in cool, wet springs, attract the egg-laying female flies. Larvae hatch in a few days, and the maggots feed immediately on decaying organic matter or attack germinating seed and eat the germ and embryo. Damage occurs before the seedling breaks through the soil. There may be two to four generations per year, but the spring flight is most damaging.

Distribution and importance

Input provided by those who attended the Sweet Corn PMPS workshop indicated that the percentage of infestation ranges from <10 up to 100 percent and that infestation is especially a problem in early planted corn. For New England, infestations are generally less than 10 percent. In New York, infestations depend on the season, but there can be up to 60 percent damage if no seed or preplant treatment is used. In Maryland, Delaware, and New Jersey, this pest is a problem most years and always requires treatment. In Pennsylvania, it is becoming an increasing problem in earlier planted fields. This pest also tends to be a problem in organic corn where chemical seed treatments are not available.

Nonchemical control

Where green cover crops are tilled in, or manure or compost is incorporated in spring, a delay (at least 3–4 weeks) between incorporation and planting will allow time for decomposition of the residue to occur and time for seed corn maggots to mature because of the abundance of organic matter. Conditions that delay the germination of the seed and vigorous seedling emergence (e.g., cold, wet soils) favor seed corn maggot by keeping seed in a vulnerable stage longer. Hence, planting in warmer soils, shallow planting, or using clear plastic to warm the soil are nonchemical strategies for maggot control.

In organic corn, seed corn maggot can be controlled by using transplants for early plantings instead of planting into cold spring soils, or by delayed planting. Transplanting has become more widespread among organic and some conventional growers in recent years.

Floating row covers may not protect against this pest, if adult flies have already laid eggs before row covers are applied.

Chemical control (Tables 33 and 34)

There is no rescue treatment for this pest; that is, if damage to seeds is detected, it is too late to apply an insecticide. Therefore, if animal or green manure is applied to fields or damage is expected, a seed or soil treatment is commonly used. Because the damage occurs directly to the seed, treatments must be on or near the seed, but they do not have to be long lived to be effective. Neonicotinoids are common seed treatments, whereas organophosphates and pyrethroids are used as band or furrow treatments at planting.

Table 33 reports information provided by 207 New England sweet corn growers regarding their management of seed corn maggot and the use of chemical control. Of those 207 growers, 158 (77 percent) indicated that they used no chemical control. The 1,269 acres treated by the 49 growers that used some type of chemical pest control for seed corn maggot, represent treatment of 28 percent of the sweet corn acreage. This table also shows how those who used each individual chemical would rate the efficacy of the chemical from excellent to poor.

Table 33. Use patterns of New England growers for nonchemical and chemical control of seed corn maggot

Nonchemical	**# Growers**	**% Growers**	**# Acres**	**% Acres**	**Excellent**	**Good**	**Poor**
Plant later	1		1				
Pesticide							
Gaucho 600	27	13	759	17	16	11	0
Lorsban 4E	13	6	623	14	10	3	0
Treated seed	6	3	147	3	0	2	0
Force 3G	1		100	2	1	0	0
Cruiser 5FS	6	3	70	2	3	3	0
Diazinon	4	2	16	<1	3	1	0
Counter 15G	1		7.5	<1	0	1	0
Kernal guard	1		5.2	<1	1	0	0
Fortress 5G	0						
Capture 2EC	0						
Thimet 20G	0						

Comments of workshop participants regarding specific chemical control methods for seed corn maggot are provided in Table 34.

Table 34. Chemical control efficacy for seed corn maggot as rated by participants at the Sweet Corn PMSP workshop

Pesticide	Workshop Participants	% Workshop Participants	E	E –G	G	F–G	F	F—P	P
Lorsban	2	14	2						
Force	2	14	1		1				
Furadan	1	7			1				
Gaucho	2	14					2		
Capture	2	14	2						
Counter	2	14	2						
Cruiser	2	14					2		
Diazinon	3	21	2		1				

Other Insect Pests

Sap Beetles (*Carpophilus* spp.)

These beetles (fourspotted sap beetle or "picnic beetle," or dusky sap beetle) generally are secondary pests attracted to damaged plant tissue such as decaying pollen and browning pollen, and tissue damaged by other insects and animals. They feed on many types of damaged or decaying vegetables and fruits and are considered secondary invaders of injured plants. Adults overwinter either in the soil or in sheltered aboveground locations. Adults feed on ripening pollen, damaged tissue, or frass left by other insects in tassels or stalks, and kernel tissue. Their feeding may allow fungal pathogens to get into the plant or ear. Adult feeding in corn often follows damage by European corn borer or corn earworm to tassels, stalks, or ears. In corn varieties in which the silk channel is open or short and the tips of the ears are exposed, adult beetles may feed on kernels in the milk stage, or females may lay eggs. Eggs are laid in silks, worm frass, or damaged tissue. Larvae are creamy white, feed on kernels in groups, and grow up to about 1/4 inch in length. Each generation takes about 30 days from egg to adult, and there are several generations per year.

Distribution and importance

Distribution is throughout North America. Sap beetles are a relatively minor pest of sweet corn; however, their importance is highly variable among farms. Those present at the Sweet Corn PMSP workshop indicated that some growers in Massachusetts have a chronic problem with this pest, especially where there is other pest damage. The indication was that overall infestations can be spotty but well established in some areas. Diversified farms with fruit as well as vegetables may provide a good habitat for populations to build up and thus have more problems with this pest group. However, sap beetles also can be a problem in processing corn. The members of the Sweet Corn PMSP group felt there is a potential for sap beetles to be a major pest in Bt sweet corn fields because these are not treated, or they are treated less often, for caterpillar pests. Bt sweet corn does not control sap beetle, but infestations may be overlooked, and thresholds have not been well established. Ears that are infested with sap beetle larvae are rejected for processing and unmarketable in the fresh market.

Nonchemical control

Use of varieties with a long, tight silk channel that continues to be deep and tight all the way until harvest has been shown to have less damage from sap beetle. Some super sweet varieties tend to have more exposed tips and become infested with beetles.

Removing alternate hosts and overwintering sites may reduce populations on diversified farms. Removal would include decaying fruits and vegetables where feeding and breeding take place (e.g., discarded tomatoes, summer squash, or fruit from the vicinity) as well as fall tillage or removal of any infested corn ears or removal of dropped apples from orchards near sweet corn fields, which could serve as overwintering sites.

Maintaining good control of caterpillars reduces attractiveness of the plant to sap beetles.

Sap beetles may build up in early corn. Hence, planting late corn at a distance from early corn may reduce infestations in late corn.

Sap beetles are monitored by inspecting the silk area when fresh green silking is complete and wilted silks are present, to determine the percentage of ears infested with adult beetles, eggs, or larvae.

Chemical control (Table 35)

Participants in the Sweet Corn PMSP workshop note that products used to control corn earworm and European corn borer also may control sap beetle. However, in Mid-Atlantic and New England regions, there is anecdotal evidence of some failures with Pounce and some other materials. Warrior seems effective, although some anecdotal evidence indicates a slippage of control. The group felt that there are no products that are consistently effective for this pest.

If sap beetles are present and no treatments are being used for caterpillar control, the economic threshold recommended (Adams and Clark 2001) is to spray if 10 percent of the ears are infested with any larvae, adults, or eggs. The application window for sap beetle is from the time that silks wilt until shortly before harvest.

Table 35 reports information provided by 206 New England sweet corn growers regarding their management of sap/picnic beetles and the use of chemical control. Of those 206 growers, 188 (91 percent) indicated that they used no chemical control. The 366 acres treated by the 18 growers that used some type of chemical pest control for sap/picnic beetles, represent treatment of only 8 percent of the sweet corn acreage. This table also shows how those who used each individual chemical would rate the efficacy of the chemical from excellent to poor.

Table 35. Use patterns of New England growers for control of sap/picnic beetles

Pesticide	# Growers	% Growers	# Acres	% Acres	Excellent	Good	Poor
Lannate SP	9	4	177	4	4	3	2
Baythroid	1		136	3	0	0	0
Warrior	11	5	119	3	5	6	0
Asana XL	1		3.5	<1	1	0	0
Capture 2EC	0						
Malathion 57EC	0						
Mustang MAX	0						
Sevin XLR Plus	0						

True White Grub (*Phyllophaga* sp.), **Japanese Beetle Grub** (*Popillia japonica*), and **Wireworm** (*Melanotus* sp.)

These pests attack germinating corn or feed on roots. Adults of white grubs are the familiar, robust brown May or June beetle that come to porch lights in late spring. Japanese beetle larvae are also white grubs. These beetles are more likely to lay their eggs in fields that have extensive weed growth in midsummer. White grubs have historically been worse after sod and may be a bigger problem where forages are included in rotation with corn. They feed on corn roots and cause wilting, stunting, a purple coloring of the leaves due to poor uptake of phosphorus, or plant death. Infestations tend to be patchy. True white grubs have a 3-year life cycle in the soil, with the worst damage caused by second-year larvae or in the spring of the third year of development. White grubs tend to be an increased problem in earlier planted corn. They may be harder to control in the more mature stages in the third year.[3]

Wireworms of several species feed on a variety of grasses, including sweet corn. Adults, known as click beetles, deposit eggs in late spring; immatures feed for 3 to 5 years in the soil to complete their development. Wireworms are most commonly found in corn where the preceding crop was pasture, hay, or sod, or fallow. They do more damage in cool wet springs.

Japanese beetle adults also may feed on corn silks later in the season, clipping silks. Rarely do populations reach numbers that cause economic injury.

Distribution and importance

All of these pests are distributed throughout the northeastern United States. In general, these pests are of low-to-moderate importance as a pest problem in sweet corn production. Spring plantings are most affected.

Nonchemical control

Late summer plowing may cause mortality to grubs, before winter. Crop rotations that do not include sod and good weed (especially grassy weeds) management may reduce the attractiveness of the field to females for egg laying.

Although fall soil samples may be used to measure grub populations, the most common indicator of potential grub problems is the sight of grubs during spring plowing and tilling operations. It is important to identify the species, because annual white grubs and Japanese beetle grubs are unlikely to cause economic injury to corn, whereas true white grubs may cause such injury. Populations of two white grubs per square foot may cause economic damage (Adams and Clark 2001). Monitoring for grubs after planting requires examining the stem and roots of wilted or stunted seedlings for injury and searching for grubs in the stem or roots or in soil near the plant.

The potential for economic damage from wireworms is more difficult to predict. Preplant sampling for wireworms can be done using baits of germinating corn and wheat seed, but such sampling is time-consuming. Wireworm injury is more likely to include lack of seedling emergence as well as wilting or stunting. Sampling includes examination of the ungerminated seed and underground stem and roots.

Because of the patchy nature of infestations, samples are taken in at least 10 sites around the field.

Chemical control (Table 36)

The decision whether to use chemical control should be made before planting because seed or furrow treatments are effective, whereas rescue treatments are not. Because there are no rescue treatments, most treatments are made in anticipation of pests becoming a problem. If injury to a planted crop is sufficient to justify replanting, seed or soil treatments are used to prevent damage.

Table 36 reports information provided by 207 New England sweet corn growers regarding their management of wireworm and the use of chemical control. Of those 207 growers, 197 (95 percent) indicated that they used no chemical control. The 195 acres treated by the 10 growers that used some type of chemical pest control for wireworm, represent treatment of only 4 percent of the sweet corn acreage. This table also shows how those who used each individual chemical would rate the efficacy of the chemical from excellent to poor.

Table 36. Use patterns of New England growers for control of wireworm

Pesticide	# Growers	% Growers	# Acres	% Acres	Excellent	Good	Poor
Cruiser 5FS	3	1	73	2	1	2	0
Gaucho	1	<1	7.5	<1	0	1	0
Counter 15G	1	<1	7.5	<1	1	0	0
Kernal guard	1	<1	5.2	<1	1	0	0
Diazinon	1	<1	0.5	<1	1	0	0
Treated seed	4	2	116	3	0	1	0
Capture 2EC	0						
Force 3G	0						
Mocap 10G	0						
Thimet 20G	0						

Twospotted Spider Mite (*Tetranychus urticae*)

The twospotted spider mite has a broad host range, including grass and broadleaf weeds and other crops. They can produce multiple generations in one growing season. They feed on the underside of lower leaves, moving up the plant, causing yellowing and death of leaves. Economic losses can occur when infestations of this pest occur during ear formation.

Distribution and Importance

Occurrence of this pest is rare; however, when it does occur it can become a serious problem. Mite populations are weather dependent, with hot and dry conditions being more conducive to higher populations. Typically, mites are controlled naturally by beneficials.

Nonchemical control

In most years, they are controlled by naturally occurring diseases and natural enemies; however, prolonged periods of low humidity can suppress the fungus that naturally controls this pest and causes it to become a problem. The use of broad-spectrum insecticides to kill other pests also can decrease the population of the natural predators of this pest to the point where it may become a significant pest; however, this would be rare.

Chemical control (Table 37)

Those present at the Sweet Corn PMSP workshop indicated that they felt that only Metasystox R provides reasonable mite control. They felt that this labeled use of Metasystox R should be retained as a one time use rescue treatment. It is used rarely, in the mid-Atlantic states; however, it needs to be available in the event an infestation occurs as there are no other effective alternatives.

Table 37 reports information provided by 205 New England sweet corn growers regarding their management of twospotted spider mite and the use of chemical control.

Of those 205 growers, 204 (99 percent) indicated that they used no chemical control. The 15 acres treated by the one grower that used some type of chemical pest control for mites, represent treatment of less than 1 percent of the sweet corn acreage. This table also shows how those who used each individual chemical would rate the efficacy of the chemical from excellent to poor.

Table 37. Use patterns of New England growers for control of twospotted spider mite

Pesticide	# Growers	% Growers	# Acres	% Acres	Excellent	Good	Poor
Capture 2EC	1	<1	15	<1	0	1	0
Metasystox-R	0						

Japanese Beetle Adults (*Popillia japonica*)

Adult beetles feed on corn silk and may clip a sufficient number of silks to prevent proper pollination. Leaf feeding is seldom of importance. Grubs do not cause damage to corn roots.

Distribution and importance

Japanese beetle occurs throughout the eastern United States. A single adult emergence occurs per season, from mid-June to August. Japanese beetle is only a sporadic pest of corn. They can be a problem if there is an early infestation at fresh silk and an early silk spray is not required because of low insect populations or use of Bt corn. The damage done to the silk will disrupt pollination. It is a serious pest of many ornamentals and fruit trees, and of soybean. Soybean fields and other host crops can serve as a source of infestation for corn.

Nonchemical control

Monitoring is done at early silk stage, to determine whether beetles are present and silk damage is occurring. Sprays are needed if silks are clipped to les than 1/2 inch, fewer than 50 percent of ears have been pollinated, and beetles are feeding.

Chemical control (Table 38)

Japanese beetles are usually controlled by sprays directed at controlling European corn borer and corn earworm. Rarely, sprays are used specifically for this pest.

Table 38 reports information provided by 207 New England sweet corn growers regarding their management of Japanese beetles and the use of chemical control. Of those 207 growers, 193 (93 percent) indicated that they used no chemical control. The 91 acres treated by the seven growers that used some type of chemical pest control for Japanese beetles, represent only 4 percent of the sweet corn acreage. This table also shows how those who used each individual chemical would rate the efficacy of the chemical from excellent to poor.

Table 38. Use patterns of New England growers for control of Japanese beetles

Pesticide	# Growers	% Growers	# Acres	% Acres	Excellent	Good	Poor
Warrior	7	3	71	2	4	3	0
Sevin XLR Plus	4	2	17	<1	0	4	0
Lannate	2	1	7.5	<1	2	0	0
Ambush	1	<1	0.9	<1	0	0	0
Handpick	1	<1	2	<1	0	1	0
Capture 2EC	0						
Mustang MAX	0						

Stalk Borer (*Papaipema nebris*)

The eggs of this pest overwinter on grassy weeds. Upon hatching in the spring, the larvae feed on grasses. Perennial grasses (quackgrass) and large broadleaf weeds (waterhemp and giant ragweed) such as quack grass are the typical host of these pests. When the larvae become too large to feed within the grass, they disperse into cornfields, attacking border rows. The most severe damage comes from insects tunneling into plants and most commonly destroying the growing point of the plant.

Nonchemical control

Adjusting planting dates is not an effective control of this pest. Eliminating grassy weeds in August by mowing or use of herbicides reduces populations in subsequent years.

Chemical control (Table 39)

Scouting for injury soon after the corn emerges in the spring, and through whorl and pretassel stages, is used to determine the need for treatment. Spot applications to outer rows can be used. Sprays that target European corn borer or fall armyworm may also control this pest.

Table 39 reports information provided by 215 New England sweet corn growers regarding their management of stalk borer and the use of chemical control. Of those 215 growers, 182 (85 percent) indicated that they used no chemical control. The 515 acres treated by the 33 growers that used some type of chemical pest control for stalk borer, represent treatment of 15 percent of the sweet corn acreage. This table also shows how those who used each individual chemical would rate the efficacy of the chemical from excellent to poor.

Table 39. Use patterns of New England growers for control of stalk borer

Pesticide[2]	# Growers	% Growers	# Acres	% Acres	Excellent	Good	Poor
Warrior	21	10	402	9	13	6	1
Ambush	8	4	183	4	3	4	1
Baythroid 2	1	<1	100	2	0	0	1
Sevin	2	1	16	<1	0	1	0
Lannate	1	<1	10	<1	1	0	0
Larvin	1	<1	10	<1	1	0	0
Pounce	1	<1	3	<1	1	0	0
Asana XL	1	<1	1	<1	1	0	0
Capture 2EC	0						

Cutworms (*Agrotis ipsilon*)

Black cutworm is the most common cutworm species in this pest group. Cutworm infestations are sporadic, making it difficult to predict where they may occur. Moths migrate annually from the Gulf states, females and lay eggs in pasture and fence row grasses and on low, densely growing weeds and debris in fields that have not been tilled. Damp, low areas are especially attractive for oviposition. Cutworms destroy plants by cutting the seedling corn stems near the surface of the soil. Cutworms feed at night and hide in the soil during the day.

Distribution and importance

Cutworm infestations are sporadic. The percentage of acres infested depends on tillage and the weather conditions each year. Cold and wet seasons encourage more damage, and damage is more common in early planted corn. In addition, this pest tends to be more of a problem in fields with a previous cover crop or fields heavily infested with weeds. Populations may be more severe in no-tillage systems or in corn following sod. Tillage of weeds, sod, or cover crops, or killing weeds with herbicide, immediately before planting encourages cutworms to move to corn seedlings. Generally, this pest is not a problem in later corn plantings.

Nonchemical control

Cultural practices such as early clean tillage, avoiding planting corn in recently plowed sod, and delaying planting after initial tillage of cover crops or weeds, are the primary control methods for this pest. Monitoring moth flight with pheromone traps in late winter to determine the need for additional control, such as early tillage, can be used to aid in the management of this pest. Scouting fields when seedlings are small is used to determine the need for rescue treatments.

Chemical control (Table 40)

Comments from those present at the Sweet Corn PMSP workshop indicated that pyrethroids are the material of choice for rescue treatments, because of cost and low toxicity. Some also felt that Sevin used by smaller growers due to the fact that it is a general use pesticide.

Table 40 reports information provided by 207 New England sweet corn growers regarding their management of cutworms and the use of chemical control. Of those 207growers, 192 (93 percent) indicated that they used no chemical control. The 508 acres treated by the 15 growers that used some type of chemical pest control for corn earworm, represent treatment of 7 percent of the sweet corn acreage. This table also shows how those who used each individual chemical would rate the efficacy of the chemical from excellent to poor.

Table 40. Use patterns of New England growers for control of cutworms

Pesticide	# Growers	% Growers	# Acres	% Acres	Excellent	Good	Poor
Lorsban 4E	6	3	386	9	3	2	0
Warrior	4	2	72	2	2	2	0
Sevin XLR Plus	3	1	38	<1	2	0	1
Asana XL	1		12	<1	1	0	0
Ambush	0						
Baythroid 2	0						
Capture 2EC	0						
Mustang MAX	0						

Weed Pests

Primarily, weeds cause reduction in sweet corn yield because of competition for soil moisture and nutrients. In many fields, competition for nutrients, especially nitrogen, is very important. However, weeds also can harbor insect pests that cause yield losses as well as cosmetic damage. In rare cases, when weeds grow faster and taller than the corn crop, shading can contribute to yield losses. It is the competition for soil moisture that causes the most significant yield losses, particularly in years when rainfall is low, or especially under drought conditions (limited rainfall and high temperatures). Drought conditions can, in turn, lead to a reduction in herbicide effectiveness and thus higher weed populations. If a high, dense weed population causes corn plants to be stunted, then their ability to produce a large ear with full kernels is hampered.

Field infestations of weeds range from no presence to 100 percent of the acres infested (Table 42). Prevalence of weeds can depend on soil type and day length, and climactic factors such as rainfall, and temperature. Weeds produce copious numbers of seeds that may lie dormant for very brief (2-week) or long (10–20 year) periods before germination. Weed seeds are distributed by wind, water, birds, and mechanical harvesting equipment. Weeds that emerge with the crop must be controlled in less than 28 days after planting. Once they are controlled they must be maintained below an acceptable population until 6 weeks after planting. An acceptable weed population is less than 0.5 weed per 10 feet of row. To a lesser extent, weeds, especially when dense, can cause a reduction in harvesting efficiency if they clog mechanical pickers.

Weeds can primarily be grouped in three categories: annual grasses (including winter annuals and cover crops), annual broadleaves, and perennials (grasses and broadleaves). Although growers face a variety of weed problems, they indicated that pigweed, crabgrass, lambsquarter, foxtails, and common ragweed were the most common weed pests. When asked to rank the most significant weed pests requiring the most management (Table 41), 91 percent of the 209 New England growers who responded ranked annual broadleaf weeds as the most significant weed pest. Eighty percent felt that annual grasses were the most significant weed problem, followed by perennial broadleaf weeds at 58 percent and perennial grasses at 54 percent.

Table 41. Ranking of most significant weed pests requiring the most frequent management based on responses from 209 New England sweet corn growers

Rank	Weed	Annual Management
1	Annual broadleaf weeds	**190**
2	Annual grasses	**168**
3	Perennial broadleaf weeds	**121**
4	Perennial grasses	**113**

Table 42. Percentage of sweet corn acres infested with weeds in the northeastern United States based on information provided by workshop participants

Weed Pest	**% Acres Infested**							
	Grower							
	1	2	3	4	5	6	7	8
Cocklebur		0				30		
Common ragweed		10		80	100	100	20	
Giant ragweed						5		
Jimsonweed		10				100[3]		
Lambsquarter		100[X]		75	100	100[4]	100[1]	
Morning glory		50			30	100[2]	40[4]	
Nightshade		30			40	60	20	
Pigweed/waterhemp		100[X]		90	100	100[5]	100[3]	
Smartweed		0			70	100	40	
Velvetleaf		0		10	10	100[1]		
Barnyard grass		0			50	100	20	
Crabgrass		50			80	100	100[2]	
Fall panicum		100[X]			70	100	20	
Field sandbur	Edge problem	0						
Foxtails		100[X]		50	60	100	30	
Milkweed		10		50	10	50	40	
Johnsongrass		0		50		60		
Nutsedge		0				80	50	
Quackgrass		0		50	20		30	
Yellow nutsedge		0			70		50[5]	
Bromegrass		0				60		
Henbit/chickweed		10			40	100		
Horseweed		0				100	20	
Mustard		10			40	100		
Others Listed one grower		Purslane (100)				Canada thistle		Field bindweed, shattercane

Herbicide use data

The information in Tables 43–46 indicates the overall total percentage of fields treated with herbicides and the amount of insecticides used in New Jersey, New York, and Pennsylvania for fresh market sweet corn production, and the total amounts specific herbicides used in each state. Because of the small sample size of growers who produce sweet corn for processing, data for insecticide use on processed sweet corn are available only for New York. Table 47 indicates the amounts of specific insecticides used in New York for processed sweet corn production. Data on amounts of herbicides used in the New England states are discussed on a per pest basis.

Table 43. New York, New Jersey, and Pennsylvania overall herbicide use in fresh sweet corn[1]

State	2004 Acres Planted	%of Fields Treated with Herbicides
New Jersey	8,200	76
New York	29,000	86
Pennsylvania	21,800	93

[1]Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.

Table 44. Specific herbicide use patterns in New Jersey fresh market sweet corn

Herbicide active Ingredient	Area Applied (%)	Applications (#)	Rate/Application (Pounds/Acre)	Rate/Crop Year (Pounds/Acre)	Total Applied (1,000 pounds)
Alachlor	20	1.0	1.61	1.61	2.6
Atrazine	56	1.1	1.35	1.46	6.8
S-Metolachlor	55	1.0	1.32	1.34	6.1

Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary

Table 45. Specific herbicide use patterns in New York fresh market sweet corn[1]

Herbicide Active Ingredient	Area Applied (%)	Applications (#)	Rate/Application (Pounds/Acre)	Rate/Crop Year (Pounds/Acre)	Total Applied (1,000 pounds)
Alachlor	23	1.0	2.02	2.09	13.7
Atrazine	80	1.1	1.21	1.30	30.2
Bentazon	8	1.0	0.86	0.86	2.1
Butylate	2	1.0	3.77	3.80	2.4
Dimethenamid	7	1.0	1.06	1.06	2.2
Glyphosate	3	1.1	0.84	0.92	0.7
Pendimethalin	23	1.1	0.95	1.00	6.6
S-Metolachlor	40	1.0	1.30	1.35	15.8

[1]Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.

Table 46. Specific herbicide use patterns in Pennsylvania fresh market sweet corn[1]

Herbicide Active Ingredient	Area Applied (%)	Applications (#)	Rate/Application (Pounds/Acre)	Rate/Crop Year (Pounds/Acre)	Total Applied (1,000 pounds)
2,4-D	1	1.0	1.00	1.00	0.1
2,4-D Dimeth.	1	1.0	0.43	0.43	0.1
salt	9	1.6	1.34	2.09	3.9
Alachlor	90	1.1	1.28	1.41	27.7
Atrazine	8	1.0	0.86	0.89	1.6
Bentazon	1	1.0	0.01	0.01	([2])
Carfentrazone-	2	1.0	1.16	1.16	0.6
ethyl	9	1.0	.77	.78	1.5
Dimethenamid	13	1.1	1.11	1.17	3.4
Glyphosate	71	1.0	1.76	1.80	27.7
Pendimethalin					
S-Metolachlor					

Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.

Table 47. Specific herbicide use patterns in New York processed sweet corn[1,2,3]

Herbicide Active Ingredient	Area Applied (%)	Applications (#)	Rate/Application (Pounds/Acre)	Rate/Crop Year (Pounds/Acre)	Total Applied (1,000 pounds)
Alachlor	66	1.0	2.61	2.61	33.6
Atrazine	94	1.0	0.64	.66	12.1
Bentazon	77	1.0	0.56	0.58	8.8
Pendimethalin	12	1.0	1.26	1.26	2.8
S-Metolachlor	25	1.0	1.18	1.18	5.8

[1]Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.
[2]Planted acreage in 2004 was 19,500.
[3]Total applied is less than 50 pounds.

Key Weed Pests in Northeast Sweet Corn Production

Pigweed (*Amaranthus retroflexus*, *A. hybridus*, and *A. powellii*)

Pigweeds are prolific seed producers: one plant can produce more than 100,000 seeds in a growing season. The seeds of pigweed species may remain viable for years. Pigweeds are a problem in no-tillage fields because undisturbed soils favor germination of the minuscule seeds, and the debris keeps the field moist, allowing extended germination. Other favorable germination field 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.

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

Common waterhemp is a native pigweed species, and growers indicated it can be a serious weed problem. Changes in agricultural practices that favor this weed include reductions in tillage, herbicide selection, simplified crop rotations, and recent weather patterns. Many local factors also have contributed to the increase in common waterhemp populations, including 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 because of resistance to several 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.

Crabgrass (*Digitaria* spp.)

Growers felt this warm-season grass was one of the most significant weed problems in the region. The plants root at the nodes and because of a high root-to-shoot ratio may be very competitive where moisture is limiting. Crabgrass infestations may be most severe during the late part of the growing season after herbicides have degraded, when holes remain in the canopy, or a combination. Tillage and row cultivation help in control of crabgrass species. Crabgrass is an increasing problem according to growers.

Common Lambsquarter (*Chenopodium album*)

Common lambsquarter produces numerous small seeds that germinate after an overwintering process. Optimal temperature for germination is 70°F, but seeds can germinate between 40 and 94°F, which suggests early germination capability. Survival is favored by rains that dilute or leach herbicides from the soil surface. Triazine resistance can be a serious problem in common lambsquarter.

Foxtails (*Setaria* spp.)

Three important foxtail species occur in the northeastern United States: 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. As a result of prolific 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 herbicides provide control that aids in reducing early season competition.

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.

Other Weed Problems in Sweet Corn Production

Most of the information in this section was adapted with permission from the authors of the North Central States Sweet Corn PMSP.

Annual Grasses

Grass weeds germinate at soil depths from 1/8 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. Although usually not as competitive as broadleaf weed species, annual grasses can reduce crop yields when significant populations are present, particularly in dry years, when competition for moisture early in the season can be critical for sweet corn development. Many of these grasses are controlled with preemergence herbicide applications and tillage.

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-tillage fields where undisturbed soils favor germination. Fall panicum has shown some tolerance to atrazine and can be a serious problem.

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 common in low, moist, warm soils.

Field sandbur (*Cenchrus pauciflorus* and *C. longispinus*)

Growers indicated that field sandbur, a summer annual weed common in sandy soils, is commonly only a problem along the field edge. In addition to the issues of competition, the bur of field sandbur can injure scouts and fieldworkers.

Nonchemical control

Tillage before planting is an important method of annual grass control. Repeated tillage may accelerate reduction in 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 nonchemical control, such as crop rotation and adjusting planting dates tend to change the relative mix of species in fields, but they do not significantly reduce competition from annual weeds overall. Field sanitation and the use of certified and clean seed reduce the spread of many weed species and are both highly recommended practices.

Chemical control (Table 48)

Table 48. Chemical control for annual grass weeds

Pesticide	Common Name	Rate	PHI (days)	REI (hours)	Class
Lasso 4EC	Alachlor	1.5–3 pounds/acre	na[1]	12	Acetanilide
Sutan+ 6.7E	Butylate	3–6 pounds/acre	na	12	Thiocarbamate
Frontier 6.0	Dimethenamid	16–32 ounces/acre	50	12	Acetanilide
Eradicane 6E	EPTC + safener	2- 4 quarts/acre	na	12	Thiocarbamate
Dual Magnum II	S-Metachlor	0.96–1.91 pounds/acre	na	12	Acetanilide
Scythe 4.2	Pelargonic acid	4–6 ounces/gallon water	na	24	Pelargonic acid
Prowl 3.3EC Prowl H_2O	Pendimethalin	0.75–2.5 pints/acre 2–4 pints/acre	na	24	Dinitroanilines

[1]na, not applicable.

Winter Annual Weeds and Cover Crops

Winter annual weeds start their growth in the fall and complete their life cycle in the spring, often bearing seed in May or June. Although discing, plowing, and field cultivation tillage are effective for all winter annuals, no-tillage 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. Weeds present in the field early in the season may attract damaging insects and provide an environment for suitable for egg laying. Growers felt that four winter annual weeds had the potential to be a significant problem.

Common Chickweed (*Stellaria media*)

Common chickweed produces prolific amounts of seed and a thick mat of low vegetative growth. This weed 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*)

Horseweed produces a large amount of seed that is windborne. Resistant biotypes of this weed to glyphosate have been identified. This weed also can serve as a reservoir for viruses.

Henbit (*Lamium amplexicaule*)

Henbit is a low-growing (5–9 inches in height) winter annual. It can produce a thick mat of growth early in the growing 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. Although usually less aggressive than henbit and common chickweed in terms of population expansion, mustards are serious competitors with crops. Mustards "luxury consume" nitrogen when they begin to initial flower buds and can induce severe nitrogen deficiency, especially in early season corn.

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 sweet corn crop.

Nonchemical control

Tillage before planting effectively eliminates competition from winter annual weeds. On heavy soils, Tillage opens up the soil structure. Moldboard plow can help control weeds in some instances. The weed species that are present depend on rotation regimes within the area where sweet corn is planted.

Annual Broadleaf weeds

Broadleaf weeds germinate at soil depths from 1/8 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 factors such as moisture availability and soil temperature. Weeds produce a significant number of seeds that may lie dormant for very brief (2 weeks) or very long (30–50 years) periods before germination.

Nightshade

Nightshade, a summer annual, can produce thousands of berries; each berry can contain up to 50 seeds. All parts of a nightshade plant are considered potentially poisonous. Tillage and row cultivation are effective for early, newly emerged seedlings.

Common Cocklebur (*Xanthium strumarium*)

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

Common Lambsquarter (*Chenopodium album*)

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

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. The shade of its leaves in shorter crops increases yield loss because of decreased nutrient uptake. Jimsonweed also contains the toxic alkaloids atropine, hyoscyamine, and hyoscine. Even small amounts of jimsonweed can cause problems during harvest.

Morning glories (*Pomoea* spp.)

Tall morning glory and ivyleaf morning glory are the two major annual morning glory species. The seeds of these summer annuals may survive for several years in soil. Annual morning glories adapt to crops by vining around the crop; as a result, shading by the canopy is not particularly successful in reducing growth. Newly emerged seedlings can be controlled by tillage and cultivation, but these practices may result in conditions that favor emergence by weeds deeper in the soil profile. After vines begin to twine around the stems of the crop, cultivation may not be as effective. This can be one of the more significant weed pests in sweet corn crops.

Pennsylvania Smartweed (*Polygonum pensylvanicum*)

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

Velvetleaf (*Abutilon theophrastus*)

Velvetleaf can be a significant annual broadleaf weed in most sweet corn. Velvetleaf is a serious competitor for moisture under drought conditions. This weed also can easily grow as tall as corn and compete for light. Cultivation can partially control velvetleaf when used early in the growing season.

Nonchemical control

Tillage before planting is an important method of annual broadleaf control. Repeated tillage may accelerate reduction in 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 it does not remove enough weeds by itself to result in significantly reduced weed seed numbers in the soil. Field sanitation and the use of certified and clean seed reduce the spread of many weed species and are highly recommended practices.

Chemical control (Tables 49–52)

Table 49. Chemical control for annual broadleaf weeds

Pesticide	Common Name	Rate	PHI (Days)	REI (hours)	Class
Evik 80W	Ametryn	2–2.5 pounds/acre	na[1]	12	Triazine
Aatrex 4L	Atrazine	1–2 pints/acre	na	12	Triazine
Laddock	Atrazine + bentazon		na		Triazine
Bicep	Atrazine + metolachlor		na		Triazine Chloracetanilide
Basagran 4E	Bentazon	0.75–1 pound/acre	na	48	Benzothiadiazinone
Aim 40 WG	Carfentrazone	0.008 pound/acre	na	12	Aryl triazolinone
Stinger	Clopyralid	0.047–0.25 pound/acre	na		Pyridine carboxylic acids
Permit 75 WSG Sandea 75WG	Halosulfuron	0.023– 0.031 pound/acre	na	12	Sulfonylurea
Lorox 50 DF	Linuron	1.25–3 pounds/acre	na	24	Urea
Callisto 4EC	Mesotrione	6.0–7.7 ounces/acre	45	12	Cyclohexanedione
Scythe 4.2	Pelargonic acid	4–6 ounces/gallon water	na	24	Fatty Acid
Princep 80WP	Simazine	2.5–3.75 pounds/acre	na	12	Triazine
2,4-D amine (Amine 4)		0.25–0.5 pound/acre	na	48	Phenoxy acetic acid

[1]na, not applicable.

Table 50. Preemergence soil-applied annual grass and broadleaf herbicides based on a response from New England growers (n = 203)

Pesticide	# Growers	% Growers	# Acres	% Acres	Excellent	Good	Poor
Aatrex 4L	80	37	2,524	56	31	45	3
Dual Magnum	76	35	2,119	47	35	36	4
Bicep Magnum	50	23	1,267	28	17	32	1
Prowl H20	49	23	1,196	27	16	29	2
Lasso 4EC	24	11	2,119	25	7	16	0
Bicep Lite Magnum	27	13	493	11	12	13	2
Eradicane 6E	7	3	349	8	3	4	0
Sutan+ 6.7E	8	4	340	8	2	4	1
Princep 80WP	18	8	281	6	4	14	0
Frontier 6.0	3	1	87	2	1	2	0
Laddox	6	3	176	4	1	3	0
Sutazine 6ME	0						

Table 51. Postemergence-applied annual grass and broadleaf herbicides based on a response from New England growers (n = 202)

Pesticide	#Growers	%Growers	#Acres	%Acres	Excellent	Good	Poor
Basagran 4E	51	24	1038	23	20	29	2
Aatrex 4L	46	21	952	21	18	25	1
Permit 57 WDG	29	13	480	11	11	18	0
Amine 4	10	5	192	4	5	5	0
Dual Magnum	4	2	71	2	3	1	0
Crop Oil	1		70	2	0	0	0
Bicep	2	1	29	<1	0	2	0
Laddox	2	1	29	<1	1	0	0
Lorox 50DF	2	1	13	<1	1	1	0
Microtech	1		4	<1	0	1	0
Scythe 4.2	0						
Evik 80W	0						

Perennial Weeds

Grasses

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 it may further distribute the weed throughout the field and exacerbate the problem. Perennial grasses tend to grow more actively during the late spring and summer. Quackgrass, which grows early in the spring and in the fall, is a cool-weather species, and therefore an exception to this rule. With the introduction of effective herbicides and decline in pasture rotations, the presence of many perennial grasses has declined. According to growers, three perennial grasses tend to be somewhat problematic.

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 soil surface. Overall, this weed is decreasing in significance.

Johnsongrass (*Sorghum halepense*)

Johnsongrass produces large rhizomes that can be spread throughout the field, making it difficult to contain and control. Johnsongrass is also a reservoir for MDMV.

Yellow Nutsedge (*Cyperus esculentus*)

Yellow nutsedge causes the most severe perennial weed infestations and was reported by some growers to be a significant weed problem. This weed reproduces from tubers; 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 3 years in many soils.

Nonchemical control

Tillage before planting tends to reduce the growth of some perennial weeds (e.g., nutsedge) that germinate early. Repeated tillage is sometimes the only effective method of perennial weed control. Row crop cultivation also may impact perennial weeds and reduce weed competition. Field sanitation reduces the introduction of some perennial weed species and is a recommended practice. To be effective, perennial weed control requires a significantly higher degree of commitment, costs more money, and may affect a field's crop rotation sequence. Perennial weeds can be controlled by carbohydrate starvation. Perennials emerge in the spring by relying on carbohydrates stored in roots, rhizomes, stolens, tubers, bulbs, or nutlets. Control measures should start when the carbohydrate reserves in the weed are at their lowest. This state is often after the weed has used stored reserves to overwinter and emerge in the spring. Beginning when the weed shoot(s) break the soil surface, carbohydrate flow continues from the root toward the shoots for an additional 7 to 10 days to establish a leaf canopy. Between 10 and 14 days is a transition period. Within 14 days of emergence, the weed moves carbohydrates from the leaves back down into the root.

Starvation of perennial weeds is accomplished by never allowing the weeds to move carbohydrates down into the roots. This can be accomplished by tilling (or close mowing of tall upright weeds) every 7 to 10 days until they cease to attempt to emerge. It is critical that no timing be missed or be late. One single missed tillage can negate all the effort expended up to that point. To be successful, growers must expect to continue this effort for 4 to 6 months. Success may require more time if the effort was not started when carbohydrate reserves in the weed were low at the start of the process.

Typically, a field is fallowed and shallowly tilled on a weekly schedule for one growing season to eliminate a perennial weed problem. Begin with the first sign of the emergence of the weed in the spring. Maintain a 7-day tillage schedule. This time schedule provides about a 3- to 7-day cushion in the event of a wet period when the field can not be tilled. The schedule must be maintained and must be a high priority for the grower. One, single missed tillage can negate all the effort expended up to that point. Advance the schedule when wet weather is anticipated rather than suffer a delay. The reason for missing the timing is not important. Preventing any carbohydrate from moving from the leaves back into the root is critical for success until the weed is dead.

A field need not be fallowed for the year, provided the grower maintains a 7-day cultivation and hoeing schedule. The weekly tillage cannot be stopped when the crop becomes established. The weekly tillage and hand hoeing must be continued until the weed is dead.

Perennial Broadleaf Weeds

Although perennial weeds do produce seeds, the majority of plants listed propagate vegetatively. Most perennial weeds begin growth early in the season before crops are planted, and they also may have a very active period of growth after the crop has been harvested. Tillage can be effective for controlling many perennial weeds, but it also may distribute viable rhizomes, roots, and tubers throughout the field if done improperly. The occurrence of perennial broadleaf weeds is highly dependent on the tillage regime used in sweet corn production. Because most perennial broadleaf weeds do not tolerate tillage, these weeds are more of a problem in reduced tillage and no-tillage fields.

Common Milkweed (*Asclepias syrica*)

Common milkweed 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 3 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 these practices are less effective in controlling plants arising from rootstocks.

Nonchemical control

Tillage before planting tends to reduce the growth of some perennial weeds that germinate early. Repeated tillage, although not always compliant with conservation tillage practices, is sometimes the only effective method of perennial weed control. Row crop cultivation also may impact perennial weeds and reduce weed competition. Other methods of nonchemical control, such as adjusting planting dates, are seldom used. Field sanitation does reduce the introduction of some perennial weed species and is a recommended practice. Timing is critical; if done improperly, tillage may result in the spread of rhizomes or rootstock and enhance 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 areas where sweet corn is planted.

Chemical control (Table 52)

Table 52. Chemical control for perennial weeds

Pesticide	Common Name	Rate	PHI (days)	REI (hours)	Class
Roundup 4S	Glyphospate	1– 3 ounces/gallon	na[1]	12	Glyphosate
Gramoxone	Paraquat	2 quarts/acre	na	12	Bipyridilium

[1]na, not applicable.

Gramoxone Max 3SC. A 24C (Special Local Need) label has been approved in Maryland and Virginia for postharvest desiccation of the crop.

Table 53 reports information provided by 197 New England sweet corn growers regarding their use of chemicals to manage perennial weeds. Of those 197 growers, 138 (73 percent) indicated that they used no chemical control. The 483 acres treated by the 59 growers that used some type of stale bed chemical application represent treatment of 11 percent the sweet corn acreage. This table also shows how those who used each individual chemical would rate the efficacy of the chemical from excellent to poor.

Table 53. Chemicals used to manage perennial weeds based on input from New England growers

Pesticide	# Growers	% Growers	# Acres	% Acres	Excellent	Good	Poor
Roundup 4S	59	27	483	11	40	15	2

Stale Bed Applications

Tables 53 and 54 report information provided by 203 New England sweet corn growers regarding their weed management practices in stale beds. Of those 203 growers, 182 (90 percent) indicated that they used no chemical control. The 186 acres treated by the 21 growers that used some type of stale bed chemical application represent treatment of 4 percent the sweet corn acreage. This table also shows how those who used each individual chemical would rate the efficacy of the chemical from excellent to poor. In addition three growers indicated they used non chemical control methods listed and rated in Table 54.

Table 54. Nonchemical control used by New England sweet corn growers in stale bed applications

Nonchemical Control	# Growers	% Growers	# Acres	%Acres	Excellent	Good	Poor
Flaming	1		12	<1	0	1	0
Mechanical	2	1	3.4	<1	0	0	0

Table 55. Chemical use patterns of New England growers in stale seed bed applications

Pesticide	# Growers	% Growers	# Acres	% Acres	Excellent	Good	Poor
Roundup 4S	17	8	122	3	11	4	1
Gramoxone Max 3S	2	1	24	<1	1	1	0
Bicep II	1	<1	15	<1	0	1	0
Bicep	1	<1	10	<1	0	1	0
Aatrex	1	<1	15	<1	0	0	0
Scythe 4.2	0						

The following herbicides are nonselective and are used to control weeds that are present in a field before planting sweet corn or before sweet corn seedlings emerge. If a grower is using "no-tillage" or "minimum tillage," these herbicides also are used to kill the cover crop that may be present in the field.

Glyphosate (Roundup 4S) (and other labeled glyphosate formulations). Apply to emerged annual or perennial weeds before crop emergence. Do not treat more than 10 percent of the total field area to be harvested (TN). Do not feed crop residue to livestock for 8 weeks after treatment. Consult the manufacturer's label for specific weeds and rates. May be tank mixed with atrazine, simazine, or alachlor. After harvest, it may be applied to actively growing quackgrass that is 6 to 8 inches in height. Wait at least 5 days and then plow. Do not plant subsequent crops other than those on the label for 30 days after application. Most effective on bindweed and milkweed after bloom. Add other glyphosate formulations.

*Paraquat (Gramoxone Max *3S, Gramoxone Inteon 2.76SC).* Apply in 20- to 60-gallon spray mix to emerged annual weeds before crop emergence as a broadcast or band treatment. Product may be extremely harmful to user if not applied correctly. It is often applied before planting for burndown, but it may be used as a postdirected application (TN). Field should be prepared several days ahead of planting and treatment to allow maximum weed emergence. Plant with a minimum of soil movement for best results. Use a nonionic surfactant at a rate of 16 to 32 oz per 100 gallons of spray mix. May be tank mixed with atrazine or simazine preemergence.

Grass Weed Control

Soil-Applied Grass Herbicides

The following herbicides control most annual grasses as well as certain smaller seeded broadleaf weeds. Some growers may find that the weed control spectrum of these herbicides may be sufficient to allow use of only one of these herbicides without the addition of a broadleaf weed herbicide.

Dimethenamid (Frontier 6.0)

May be applied preplant surface, preplant incorporated, preemergence, or postemergence (up to 8-inch-tall corn). A split application may be used. This chemical will not control emerged weeds or yellow nutsedge. There is a potential for some varietal susceptibility to injury.

Pendimethalin (Prowl H20)

Apply preemergence only after seeding. Do not incorporate into the soil. A broadleaf herbicide such as atrazine or simazine also should be used to control broadleaf weeds. If this herbicide is moved into the seed zone, there is potential for crop injury. Some basic suggestions for minimizing the potential for crop injury are to plant in a firm seedbed, plant corn seed at least 1.5 inches in depth, plant into moist rather than dry soil, do not mix Prowl with liquid fertilizers, and avoid sandy soils. If the soil is dry, consider irrigating instead of waiting for rainfall before application. If heavy rains follow an application to dry soil, Prowl can move to the seed zone and cause crop injury. Specific weeds for which this herbicide should be considered include triazine-resistant lambsquarter and velvetleaf. Growers may consider a lower rate of Prowl in addition to using a broadleaf herbicide and another grass herbicide such as Dual Magnum (metolachlor), Lasso (alachlor), Frontier (dimethenamid), Sutan+ (butylate), or Eradicane (EPTC + safener).

Preplant-Incorporated Herbicides (Thiocarbamate Family)

These herbicides must be broadcast over the soil surface and incorporated before seeding.

Butylate (Sutan+ 6.7E)

Apply before planting and immediately work into soil with a disc to a depth of 2 to 3 inches for annual grasses and 4 to 6 inches for nutsedge. This product provides suppression of rhizome johnsongrass, bermudagrass, and nutsedge. Weak on many broadleaf weeds. May be tank mixed with atrazine or cyanazine to improve broadleaf weed activity.

EPTC + safener (Eradicane 6E)

Apply 2.7 to 4 quart/acre (REI 12 hours, Group 8). Provides similar grass weed control to butylate but offers better control of pigweed and velvetleaf. Must be incorporated immediately to a depth of 2 to 3 inches. May be tank mixed with atrazine or cyanazine to improve broadleaf weed activity.

Soil Surface-Applied Herbicides (Acetanilide Family)

These herbicides are usually applied to the soil surface immediately after seeding. They also can be applied after crop emergence as part of a reduced rate program.

Alachlor (Lasso 4EC)

Apply to the soil surface after seeding. Provides preemergence control of several grasses and several annual, small-seeded broadleaf weeds. Generally, weak on lambsquarter and ragweed. May also be applied after crop emergence to weed-free soil before crop is 5 inches in height. May cause some temporary crop burn if applied after corn emergence.

S-Metolachlor (Dual Magnum)

Apply to the soil surface after seeding. Provides preemergence control of several annual grasses and several annual small-seeded broadleaf weeds. Poor control of lambsquarter. May also be applied after crop emerges to weed-free soil before crop is 5 inches in height.

Postemergence Applied Grass Herbicides

Pelargonic acid (Scythe 4.2)

Use a 3–5 percent solution for annual weeds (4–6 ounces/gallon water, a 5–7 percent solution for biennial and perennial weeds (6–9 ounces/gallon water), and 7–10 percent solution for maximum burndown (9–13 ounces/gallon water). Delivery rate for boom applications should be 75 to 200 gallons of spray solution/acre; complete coverage of weed foliage is essential. Use a direct/shielded spray; contact with crop will cause injury. For hand-held equipment, spray to completely wet all weed foliage but not to the point of runoff. Repeat applications as necessary. Tank mixes are allowed with this product, including tank mixes with glyphosate (Roundup), sulfosate (Touchdown), and residual herbicides. See label for complete details.

Broadleaf Weed Control

Soil-Applied Broadleaf Herbicides (Triazine Family)

The following herbicides provide excellent control of most broadleaf weeds and are commonly used as a supplement to one of the grass herbicides discussed above. Although these herbicides are usually applied to the soil surface immediately after seeding, they also can be soil incorporated if tank mixed with a preplant-incorporated grass herbicide.

Atrazine (Aatrex 4L)

Atrazine is a photosystem II inhibitor that does not control certain weeds, such as fall panicum or smooth crabgrass. This treatment can be used as the primary broadleaf herbicide treatment instead of an application at planting, or it can be used as an emergency treatment if the soil-applied broadleaf herbicide treatment failed. If applied correctly, this application will control the emerged weeds and will continue to provide residual control for later emerging broadleaf weeds. Apply preplant incorporated or to the soil surface immediately after planting. Use alone only if annual grasses are not a problem. Shallow cultivation may help to control annual broadleaf weeds. May be tank mixed with butylate, EPTC + safener, alachlor, metolachlor, glyphosate, or paraquat. There is some residual control with this product. Only 1-pound active ingredient of atrazine is recommended for sweet corn in New England. This rate is well below the rate on the label and constitutes best management practices for groundwater protection. This rate could be reduced further, although the grower should be prepared to make a second application of atrazine if any weeds escape.

Simazine (Princep 80WP)

Simazine is a photosystem II inhibitor and is applied as a preplant incorporated or to the soil surface immediately after planting. Used for control of broadleafs (pigweed, purslane, and morning glories), and grassy weeds on a variety of deep-rooted crops. This product has a short residual. Use alone only if annual grasses are not a problem. May be tank mixed with EPTC + safener.

Mesotrione (Callisto 4EC)

Apply after seeding to the soil surface. Use 3 to 6 ounces/acre if tank mixing with atrazine. In a tank mix, the atrazine rate can be reduced to 0.5–1 pints/acre. A grass herbicide also must be used. Callisto provides excellent control of many problem broadleaf species, such a velvetleaf and triazine-resistant lambsquarter. On cool soils in the spring, Callisto may be a better option than using Prowl to control these two weed species. Callisto does not provide preemergence control of yellow nutsedge. With this weed, it is important to continue to use atrazine (alone or in combination with Callisto) as well as either Dual or Lasso preemergence. A preplant-incorporated application of either Eradicane or Sutan+ also will have activity on yellow nutsedge.

Postemergence Applied Broadleaf Herbicides

The following herbicides are applied after broadleaf weeds have emerged. They can be used as the only broadleaf weed control to supplement a soil-applied grass herbicide or they can be used as an emergency treatment if the soil-applied broadleaf herbicide fails to provide adequate control. Timing is very important when using these herbicides. Be careful to check both the ideal weed stage of growth as well as the ideal timing and application precautions for the crop.

Ametryn (Evik 80W)

Apply as a postemergence directed spray on weeds after corn is at least 12 inches in height. Do not spray overtop of corn. Do not spray within 3 wk of tasseling. This product provides control of lambsquarter, morning glory, velvetleaf, ragweed, panicum, smart weed, crabgrass, pigweed, foxtail, and many other weeds. Evik should be primarily used as an emergency treatment when grass and broadleaf weeds are emerging and the use of 2,4-D is not desirable.

Atrazine (Aatrex 4L)

See information for Ametryn (Evik 80W).

Bentazon (Basagran 4E)

Apply early postemergence overtop when weeds are small and corn has one to five leaves. This product controls common ragweed, jimsonweed, smartweed, velvet leaf, annual morning glories, and yellow nutsedge. Bentazon will not control redroot pigweed and will provide only partial control of common lambsquarter, giant ragweed, and morning glory. Bentazon should be primarily used as an emergency treatment when a soil-applied broadleaf herbicide has failed. There is less chance of adjacent crop injury from spray drift than with 2,4-D.

Carfentrazone (Aim 40 WG)

Apply before corn reaches 8 inches in height to control seedling broadleaf weeds, including pigweed, common lambsquarters, eastern black nightshade, and velvetleaf. Tank mix with atrazine at reduced rates or another broadleaf herbicide to increase the spectrum of weeds controlled. Add nonionic surfactant at a rate of 1 quart/100 gallons of spray solution. Expect to see speckling of the crop foliage after application. Initially, the injury seems to be substantial, but it is not systemic and the corn outgrows the injury rapidly.

Halosulfuron (Sandea 75WG)

This herbicide provides postemergence control of many weed species that are not under drought stress. It is rain fast in 4 h. Use a nonionic surfactant at a rate of 1 to 2 quarts/100 gallons of spray or a crop oil concentrate at 1 gallon/100 gallons of spray. Control varies with type and size of weed. Species listed on the label include redroot pigweed, pokeweed, common ragweed, Pennsylvania smartweed, common sunflower, velvetleaf, wild mustard, yellow nutsedge, and wild radish. Do not cultivate for 7 days after application. Most vegetables can be planted within 12 months of application, except crucifers, carrot, leeks, onions, lettuce, beets, and spinach. Some sweet corn varieties may be injured by Sandea, and no reliable list of susceptible varieties has yet been developed. Regular sugary varieties do not seem to be more tolerant than sugar enhanced (se) types or supersweet (sh2) types. Initially, this herbicide should be used on a small scale to control problem weeds such as yellow nutsedge, ragweed, and velvetleaf, and triazine-resistant lambsquarter. Other postemergence options continue to exist. These options include Aatrex (atrazine), Basagran (bentazon), Amine 4 (2,4-D), Lorox (linuron), and

Evik (ametryn). Atrazine, Basagran, and 2,4-D have been the most commonly used. This is an extremely safe, methyl bromide alternative. However, no more than two applications can be made

Linuron (Lorox 50 DF)

Use only as a postemergence-directed treatment to corn at least 15 inches in height. Use lower rates on weeds less than 2 inches in height and higher rates on weeds up to 5 inches in height. Add 1 pint of surfactant for each 25 gallons of spray mixture.

Mesotrione (Callisto 4EC)

Postemergence applications to corn (up to 30 inches in height) should be made when weeds are no more than 3 inches in height. Do not make more than two applications per season to corn and do not exceed a total of 7.7 ounces/acre Callisto. Callisto provides excellent control of many problem broadleaf species such a velvetleaf and triazine-resistant lambsquarter. Callisto provides only partial control of yellow nutsedge and no control of ragweed when applied postemergence. Use other options if these weeds are present.

2,4-D Amine (Amine 4)

A rate of 0.5 pints/acre should be used when weeds are small and corn is 4 to 5 inches in height. The rate should be increased to 1 pint/acre as corn reaches 8 inches in height. Cultivation should not occur for about 10 days after spraying, because corn may be brittle. If air temperature is hot and soil is wet, the rates should be reduced. Esters or low-volatile ester formulations should not be used; only the amine formulation of 2,4-D should be used. All precautions should be taken to avoid spray drift to desirable broadleaf crops.

Pelargonic Acid (Scythe 4.2)

A 3–5 percent solution should be used for annual weeds (4–6 ounces/gallon water, a 5–7 percent solution for biennial and perennial weeds (6–9 ounces/gallon water), and 7–10 percent solution for maximum burndown (9–13 ounces/gallon water). Delivery rate for boom applications should be 75–200 gallons of spray solution/acre; complete coverage of weed foliage is essential. Use a DIRECTED/SHIELDED SPRAY; contact with crop will cause injury. For hand-held equipment, spray to completely wet all weed foliage but not to the point of runoff. Repeat applications as necessary. Tank mixes are allowed with this product, including tank mixes with glyphosate (Roundup), sulfosate (Touchdown), and residual herbicides. See label for complete details.

Perennial Weed Control

Several perennial weed species, including quackgrass, bindweed, and milkweed, may be present in a cornfield. The grass and broadleaf herbicides described above have limited activity on these weeds. Use of glyphosate as described below can provide excellent control of these perennial weed species.

Glyphosate (Roundup 4S)

Apply as a spot treatment BEFORE silking of corn. Do not treat more than 10 percent of the total field area to be harvested. Any crop plants receiving spray in the treated area will be killed.

Glyphosate (Roundup 4S)

Apply AFTER corn harvest to actively growing quackgrass 6 to 8 inches in height. Wait at least 5 days and then plow. Do not plant subsequent crops other than those on the label for 30 days after application. Most effective on bindweed and milkweed at or after bloom.

Formulated Mixes[1] (Prepackaged Tank Mixes)

In recent years, several products have come on the market as formulated combinations of herbicides that were often recommended in the past as tank-mix combinations of products purchased separately (Table 55).

Table 56. Formulated mixes registered for use on sweet corn

Formulated Mix	Individual Herbicides Contained in Mix
Bicep Magnum, Bicep Lite Magnum (Aatrex)	Metolachlor (Dual, Group 15) + atrazine (Aatrex, Group 5)
Laddock (Aatrex)	Bentazon (Basagran, Group 6) + atrazine (Aatrex, Group 5)
Lariat	Butylate (Sutan+, Group 8) + atrazine (Aatrex, Group 5)
Sustained 6-ME	Alachlor (Lasso, Group 15) + atrazine (Aatrex, Group 5)

Bicep Lite contains two-thirds as much atrazine as Bicep and should allow growers a better opportunity to obtain good grass control without using more atrazine than is needed.

Dual II, Bicep II, and Bicep Lite II are newer formulations which contain a safener. The safener is designed to improve the tolerance of corn to metolachlor in cold soils. For super sweets and “se” sweet.

Table 57. Effectiveness of chemical weed control for sweet corn[1]

	Barnyardgrass	Crabgrass	Fall Panicum	Foxtails	Shattercane	Johnsongrass	Quackgrass	Nutsedge	Morning Glory	Coculbur	Jimsonweed	Common Rag Weed	Smart Weed	Velvetleaf	Pigweed/Waterhemp	Lambsquarter	Nighthade
Pre-Plant Incorporated and Preplant																	
Eradicane/Sutan-EPTC & Butylate	E	E	E	E	G	G	F	G	N	P	P	P	F	G	G	F	F/G
Atrazine	F	P/F	P	F		P		P/F	F	F/G	G	G	G	F	G	G	G
Micro-tech/Partner	G	F/G	G	G	P+	G	N	F	N	N	P	N	P	P	G	P/F	G
Dual Magnum	G	G	G	G	P+	G	N	F/G	N	N	N	N	P	P	G	P	G
Prowl	G	G	G	G	P	G	P	N	P	N	N	N	F	G	F/G	F/G	P
Sandea	N	N	N	N		N		F	F	G	G	G	F	G	G	F	N
Post Emergence																	
Aim	N	N	N	N		N		N	F	P	P	F	-	G	G	G	G
Atrazine	F	F	F	F		-	F	G	G	F	G	G	G	F/G	G	G	G
Basagran	N	N	N	N		N		F	P	G	G	G	G	G	F	F	P
Callisto	N	F	P	P		P		F	F	F/G	G	G	G	G	E	G	G
2,4-D	N	N	N	N		N		P	G	F/G	P	G	F	G	G	F/G	G
Stinger	N	N	N	N		N		N	N	G	P	G	P	P	N	P	P
Touchdown	G	G	G	G		G		G	F	G	G	F	G	G	G	G	G
Postharvest																	
Gramoxone Max	F/G	F/G	F/G	G		-		G	F/G	G	G	G	P	-	G	F/G	-

Source: Adapted from [1]2006 Pennsylvania Commercial Vegetable Production Recommendation.

Table 58. Herbicide use against common weeds based on input from those attending the Sweet Corn PMSP workshop

Weed	Avg % acres infested	Preplant/Preemergence herbicide			Postemergence herbicide		
		Poor	Fair	Good	Poor	Good	Excellent
Pigweed/waterhemp[1]	98		Sutan+				Atrazine & oil, Permit
Crabgrass	83	Frontier		Atrazine, Sutan+			
Lambsquarter	75		Sutan+			Basagran	Atrazine & oil
Foxtails	68	Frontier		Atrazine			
Common ragweed	62		Sutan+			Basagran	Atrazine & oil, Permit

The weeds listed were rated as the top five weed problems in sweet corn, based on yield loss.

Table 59. Ratings for preplant or preemergence herbicide treatments used based on input from those attending the Sweet Corn PMSP workshop

Weed	Preplant or preemergence herbicide product rating		
	Atrazine	Frontier	Sutan+ (butylate)
Common ragweed			F
Giant ragweed			F
Lambsquarter			F
Morning glory			G
Nightshade			G
Pigweed/waterhemp			F
Velvetleaf			G
Barnyard grass	G	P-F	G
Crabgrass	G	P-F	G
Fall panicum	G	P-F	F-G
Foxtails	G	P-F	G
Johnsongrass	G		
Quackgrass	G		
Yellow nutsedge	F		F-G

F, fair; G, good; P, poor.

Table 60. Ratings for postemergence herbicide treatments used by sweet corn growers in northeastern United States

Weed	Postemergence herbicide product rating		
	Atrazine and oil	Basagran (bentazon)	Permit (Halosulfuron)
Common ragweed	E	G	E
Kochia		G	P
Lambsquarter	E	G	
Morning glory	E	G	
Nightshade		G	
Pigweed/waterhemp	E	G	E
Smartweed	E		E
Milkweed	E		
Yellow nutsedge		G	E
Horseweed	E		

E, excellent; G, good; P, poor.

Diseases in Sweet Corn

Diseases in sweet corn are caused by fungi, rusts, and bacteria. Weather, plant residue, and variety selection are the most common factors that affect the incidence of sweet corn diseases. For certain key diseases, insects serve as vectors for the disease-causing organisms. Although the use of seed treatments and resistant varieties has dramatically reduced the incidence of many sweet corn disease problems, several diseases still present potentially significant economic losses if not properly managed. Growers indicated that Stewart's wilt, common leaf rust, common smut, and stalk rots are the most important diseases in terms of the percentage of acres infested. Growers also indicated that seedling blight and seedling decay were potential problems, with some growers reporting 50 percent of their acres infested. Root rots, northern leaf blight, ear and kernel rots, and MDMV and Barley yellow dwarf virus Y (BYDY) occurred rarely (in <10 percent of acres planted). Grower comments and estimation of percentage of acres infected are presented in Table 60. Refer to Tables 61–63.

Table 61. Ranking of diseases requiring the most frequent management based on responses from 212 New England sweet corn growers

Rank	Disease
1	Common smut
2	Rust
3	Seed decay
4	Stewart's wilt
5	Maize dwarf mosaic virus

Table 62. Percentage of sweet corn acres infested with diseases in the northeastern United States, based on input from participants at the Sweet Corn PMPS workshop

Disease	% Acres Infested					
	Grower 1	**Grower 2**	**Grower 3**	**Grower 4**	**Grower 5**	**Grower 6**
Seed decay			<5		50	0
Seedling blight			<5		50	0
Root rots			<5		Low	0
Eyespot						0
Common smut	30	25	<10		50[1]	<1
Northern leaf blight		<10				
Northern leaf spot						
Anthracnose leaf blight						
Grey leaf spot			50			
Stewart's wilt		10–50	10		80	0
Stalk rots			<5		40	
Ear and kernel rots			<5			10
Common leaf rust	30	25–50	60	40	80	5–10
MDMV					rare	0
BYDV		<10			rare	0
Nematodes					20	0
Other		Southern corn leaf blight				0

Data are based on information provided by six growers at the December 1, 2004. Northeastern United States includes Delaware, Massachusetts, Maryland, New Hampshire, New Jersey, New York, Pennsylvania, and Vermont (see participant list on pages 2) Superscript numbers indicate top five diseases considered a problem in the grower's fields.

Table 63. Practices used to manage disease pests based on the responses of 192 New England sweet corn growers

# Growers	% Growers	Practices Used to Manage Diseases
124	58	Crop rotation
120	56	Fungicide-treated seed
105	49	Disease tolerant varieties
15	7	Application of fungicides
5	2	Other

Table 64. Nonchemical management options for sweet corn diseases based on input from participants at the Sweet Corn PMSP workshop*

Disease	Nonchemical Management Option		
	Transplants	Rotation	Resistant varieties
Seed decay	X		
Common smut		X	X
Stewart's wilt			X
Corn leaf rust			X

*Only those diseases rated in the top three and infesting at least 20 percent of the acres are listed

Table 65. Grower information used to reduce or prevent infestation by sweet corn diseases

Disease	Management		Field Conditions/Weather	Comments
	Chemical	Non-chemical		
Seed decay	Seed treatments	Transplants	Transplants, early season	Seed treatment may not work well in cold, wet years
Seedling blight		Problem in heavy, wet soils		Difficult to field diagnose
Root rot	Seed treatments; plant cultivars with good cold germ	Weather-dependent		Low susceptibility; large-acreage growers can pick the fungicide
Common smut	Rotation	Some varieties more susceptible in fields with history of inoculum; flooding increases disease incidence; physical injury allows disease entrance		Increase harvest costs in mechanically harvested field;
Northern leaf blight	Bravo, Dithane, Mancozeb, Tilt, good; Quadris, excellent	Problem in extremely wet years; dry year problems may because of irrigation		
Grey leaf spot		Problem in southern regions in wet years		Not a problem in New England or New York
Stewart's wilt		Plant resistance varieties		Control flea beetle vector
Stalk rot		Adjusting planting date not effective		Problem in southern region, not New England or New York, Pennsylvania split
Ear and kernel rot		Weather determines seriousness		Secondary infection after damaging conditions; more of a problem in processing; there are no "resistant" varieties
Common leaf rust	Quadris and Tilt, excellent	Plant resistant varieties (new rust strains?)		More common in late plantings;

Table 65 (continued). Grower information used to reduce or prevent infestation by sweet corn diseases

Disease	Management		Field Conditions/Weather	Comments
	Chemical	Non-chemical		
BYDV				Rare, but can be devastating in some fields; aphid (vector) control; watch for purplish leaf tips/margins; fields look tattered. Problem when corn planted as cover crops
Nematodes		Crop rotations (potentially prevents buildup)		Sweet corn tends to be tolerant
Southern corn leaf blight	Preventive sprays (Bravo, Dithane); Quadris, Tilt	Some tolerant varieties	Occurs in Mid-Atlantic states; could be blowing in annually	

Fungicide use data

Tables 66–69 indicate the overall total percentage of fields treated with fungicides, the amount of fungicides used in New Jersey, New York, and Pennsylvania for fresh market sweet corn production, and the total amounts specific fungicides used in each state. Because of the small sample size of growers who produce sweet corn for processing, data for fungicide use on processed sweet corn are available only for New York. Table 68 indicates the amounts of specific fungicides used in New York for processed sweet corn production. Data on amounts of fungicides used for control of rust in the New England states are discussed individually. Because of the limited amount of fungicides that are used, very little data are available.

Table 66. New York, New Jersey, and Pennsylvania overall fungicide use in fresh sweet corn[1]

State	2004 Acres Planted	% of Fields Treated with Fungicides
New Jersey	8,200	7
New York	29,000	5
Pennsylvania	21,800	9

[1]Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.

Table 67. Specific fungicide use patterns in New Jersey fresh market sweet corn[1,2]

Fungicide Active Ingredient	Area Applied (%)	Applications (#)	Rate/Application (Pounds/Acre)	Rate/Crop Year (Pounds/Acre)	Total Applied (1,000 pounds)
Chlorothalonil	4	1.3	0.71	0.91	0.3

[1]Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.
[2]Planted acreage in 2004 was 29,000.

Table 68. Specific fungicide use patterns in Pennsylvania fresh market sweet corn[1,2,3]

Fungicide Active Ingredient	Area Applied (%)	Applications (#)	Rate/Application (Pounds/Acre)	Rate/Crop Year (Pounds/Acre)	Total Applied (1,000 pounds)
Azoxystrobin	3	2.3	0.13	0.03	0.2
Chlorothalonil	2	3.2	1.48	4.72	2.2
Propiconazole	3	1.8	0.11	0.19	0.1

[1]Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.
[2]Planted acreage in 2004 was 21,800.
[3]Total applied is less than 50 pounds.

Table 69. Specific fungicide use patterns in New York processed sweet corn[1,2,3]

Fungicide Active Ingredient	Area Applied (%)	Applications (#)	Rate/Application (Pounds/Acre)	Rate/Crop Year (Pounds/Acre)	Total Applied (1,000 pounds)
Azoxystrobin	13	1.0	0.12	0.12	0.3

[1]Source: NASS, Agricultural Chemical Usage 2004 Vegetables Summary.
[2]Planted acreage in 2004 was 19,500.
[3]Total applied is less than 50 pounds.

Table 70. Sweet corn variety disease resistance

Variety	SW Resistance	Rust Resistance
Early		
Fleet	Medium	Medium
Native Gem	High	-
Seneca	Medium	Medium
Arrowhead		
Seneca		
Daybreak	Medium	yes
Sweet Chorus	Low	Medium
Second Early		
Crosswood	Medium	-
Harmony	Low	-
Sundance	no	no
Double Gem	Medium	Medium
Temptation	Medium	Medium
Trinity	Medium	Low
Jumpstart	-	-
Sweet Rhythm	Medium	Low
Sweet Ice	Medium	Low
Main		
Providence		
Lucious		
Accord		
Silver Queen	High	Low
Serendipity	-	-
Ambrosia	High	Medium
Mystique	High	Medium
Wizard	Low	Medium
Delectable	Medium	High
Precious Gem	Medium	Medium
Jackpot	Medium	yes
Lancelot	High	High
Sensor	Medium	High
Seneca Dancer	Medium	Medium
Bodacious	Medium	Medium
Tuxedo	High	High
Incredible	High	-
Immaculata	High	Medium
Silverado	yes	Medium
Silver King	Medium	High
Argent	High	Medium
Sweet		
Symphony	Medium	Low
Confection	Medium	Low
Candy Corner	Medium	High
Cabaret	High	Medium
Candy Store	High	yes
Bandit	Low	High
Ice Queen	Medium	High
Snowmass	-	-
Even Sweeter	Medium	Medium

SW: Stewar's Wilt
*Maize Dwarf Mosaic Virus

Common Rust: *Puccinia sorghi*

Common rust on sweet corn is caused by the fungus *P. sorghi*. This fungus does not overwinter in the northeastern United States. If common rust is present, it is due to migration of the fungus from the south. Thus, early planted sweet corn is not likely to develop problems with common rust. Severe rust epidemics have been rare because of the use of resistant varieties. Although they have been somewhat sporadic, rust epidemics on sweet corn can be significant when they do occur. Rust can cause dramatic reduction in both yield and ear weight. In addition, the effect of brown spots that are characteristic of this disease can significantly affect the marketability of fresh market sweet corn.

Three major factors interact to influence the outbreak of rust epidemics in sweet corn: 1) the quantity of urediniospores available to initiate rust epidemics, 2) environmental factors, and 3) the level of rust susceptibility in the sweet corn varieties in use. Weather conditions influence spore germination and the rate at which rust epidemics develop. Temperatures of 60–75°F and heavy dews or high relative humidity (close to 100 percent) favor rust development. Moisture is required for spore germination. Infection occurs when leaves are wet for a minimum of 3 to 6 hours. All plant tissues are susceptible to common rust. However, younger leaves, the first four or five leaves on the plant, are most susceptible to rust; therefore, corn plants are more susceptible to this disease before tasseling. In addition, the potential buildup of urediniospores from low levels of infection on early planted corn can create an abundance of inoculum for infecting later planted corn when the weather is conducive to disease spread.

Nonchemical control

Mainly, this disease can be controlled by the use of resistant varieties (Table 70). However, regular monitoring of fields should be done to determine whether >80 percent of the plants show one or more pustules per leaf, which particularly for fresh market corn, indicates that a fungicide application is warranted. If warranted, fungicide application should be done before corn reaches the whorl stage.

Chemical control

When chemical control is used, it is important to alternate chemicals with different modes of action to help minimize potential for resistance development.

Table 71 reports information provided by 209 New England sweet corn growers regarding their management of common rust and the use of chemical control. Of those 205 growers, 195 (95 percent) indicated that they used no chemical control for this pest. The 311 acres treated by the 10 growers that used some type of chemical pest control for common rust, represents 7 percent of the sweet corn acreage. This table also shows how those who used each individual chemical would rate the efficacy of the chemical from excellent to poor.

Table 71. Use patterns of New England growers for control of common rust

Pesticide	**# Growers**	**% Growers**	**# Acres**	**% Acres**	**Excellent**	**Good**	**Poor**
Manzate	4	2	261	6	0	4	0
Dithane	1		250	6	0	1	0
Maneb	1		250	6	0	1	0
Bravo Ultrex 82 WDG	5	2	19	<1	2	1	2
Gaucho	1		10	<1	0	0	0
Penncozeb	1		4	<1	0	1	0
Tilt	0						
Tolerant variety	1		25	<1	1	0	0

Common Smut: *Ustilago maydis*

The smut fungus overwinters in soil and can remain in the soil for 2–3 years. Smut development is favored by dry conditions and by temperatures between 79 and 94°F. This disease also can be transferred to plants by wind-borne spores, possibly over long distances. Spores also can be transferred by water.

Although all aboveground parts of the plant are susceptible, newly planted seed and younger plants are the most susceptible to common smut. Although uninjured plants can be affected, plant injury caused by hail, cultivation, and insects increases susceptibility to smut infection. An increased nitrogen level, excess manure, or herbicide injury also can increase plant susceptibility.

Common smut is characterized by the presence of large, fleshy, irregular galls on leaves, stems, ears, and tassels. Immature galls are white and spongy; mature galls turn brown and contain dark, powdery spores. The infection is spread as each kernel is individually infected through the attached silk. After pollination, the ears are protected from infection by the formation of a layer of dead cells that develops at the base of the silk. Although “common smut” is not a common disease, when it does occur it is of economic significance, mainly because there is no chemical control for this disease. There are some varieties that have a slight resistance. Seed treatments have not been effective. Unless a rotation schedule of several years is used, crop rotation and tillage are not effective control measures against common smut because the spores can survive for long periods in the soil.

Chemical control

None.

Stewart's Wilt: *Pantoea stewartii* (*formerlyErwinia stewartii*)

Stewart's wilt is more severe on younger plants than on older plants. The disease is spread when flea beetles carrying *P. stewartii* feed on corn plants. This bacterium overwinters in the stomach of the flea beetle. Even uninfected beetles can become vectors if they feed on infected plants. This disease is more common after a warm winter, which enhances survival of overwintering flea beetle populations. The best way to predict the occurrence of Stewart's wilt is when the sum of the average temperatures for December through February totals 90 or more (Penn State Vegetable Disease Identification). For example, if December's average daily temperature was 37°F and January's average daily temperature was 39°F, followed by an average daily temperature of 22°F in February (37 + 39 + 22 = 98), flea beetles carrying the bacteria can be expected, and Stewart's wilt may be a problem.

Symptoms occur first on leaves. Pale green to yellowish streaks with wavy margins may extend the length of the leaf. These streaks usually change from pale green to yellow or brown. On young plants, brown discoloration and sometimes cavities may form in the center of the stem near the soil line. Stewart's wilt can affect plants as early as the seedling emerges up until tasseling. The disease systemically infects susceptible varieties. Therefore, initial infection of seedlings can cause failure of the plant to produce a viable or marketable ear. In severe cases, early infected plants may die, late-infected plants may die, or late-infected plants may merely have streaked leaves or be stunted.

Nonchemical control

Use of resistant varieties is one of the most effective ways to manage this disease (Table 69). Monitoring the average temperatures from December through February and calculating the sum of these monthly average temperatures helps predict flea beetle presence. If flea beetle populations are expected to be high, monitoring for this beetle helps ensure early treatment.

Chemical control

Chemical control can only be achieved by control of flea beetles. Other than those chemical control methods listed in Tables 31 and 32, seed treatments (Cruiser and Goucho) are cost-effective. When chemical control is used, fields should be monitored to determine the effectiveness of the control. Monitoring is important for management decisions regarding successive treatments. If weather data and scouting indicate the potential for a high population of flea beetles, chemical control may be necessary from seedling emergence until the plants are well established.

Stalk Rots: *Gibberella zeae*, *Fusarium* sp., *Colletotrichum graminicola* (anthracnose), and *Diplodia* sp.

Plants are infected with stalk rot organisms through the roots or wounds in the stalk. Infections also can be traced to wounds caused by stalk-boring insects such as ECB. Stalk rots are dramatically affected by stress placed on the corn plants during grain fill. Stresses that potentially increase the effect of this disease are primarily weather-related (e.g., extended cool weather, hail damage, drought, or soil saturation). If potassium levels are low in relation to nitrogen levels, this imbalance also can cause stress and increase potential for stalk rot infections.

Some growers considered stalk rots to infest a high number of their sweet corn acres. However, Pennsylvania growers did not feel that this group of diseases was a significant problem.

Nonchemical control

Fields should be scouted for stalks that are rotted 40 to 60 days after pollination. If >10–15 percent of the plants show signs of rot, the field should be harvested early.

Some varieties are resistant to stalk rot, whereas other varieties are available that are so tolerant to stalk rots they do not lodge even if rot occurs.

Chemical control

None available.

Seedling Blight and Seedling Decay: *Pythium*, *Fusarium*, *Diplodia*, *Rhizochtonia*, and *Penicillium oxalicum*

All of the soil-inhabiting fungi that cause seedling blight and decay diseases, with the exception of *Pythium*, also can be seed-borne. Cool temperatures and wet conditions increase the potential for damping-off, seedling blight, and seedling rot caused by *Pythium* and *Fusarium* spp. However, the potential for *Penicillium* four-leaf dieback is increased by warm temperatures. In damping-off, the seed may rot before the plant has a chance to germinate; or germination may occur, but the seedling may be affected and blight may occur. A heavy residue on the soil surface that results in a low soil temperature and inhibits drying also encourages damping-off. If herbicide damage, soil compaction, crusting, or deeper planting depths delay germination and seedling emergence, the potential for seedling blight increases.

Nonchemical control

Plant when soil temperatures are warmer, above 50°F, and soil moisture is reasonable. These conditions are more common with a later planting date, when fields also are usually adequately drained. Seed placement of 1.5 to 2 inches is recommended; however, planting depth can vary depending on soil conditions. Crop rotations with nongrass crops can provide some control of seed rots as does control of soil insects and nematodes.

Chemical control

Generally, diseases inflicting sweet corn can be controlled only by seed treatment (see Seed Treatment, page 12) A fungicide seed treatment protects the seeds long enough for germination. When good-quality treated seed is used, fields rarely require replanting. However, without treated seed, yield losses could be significant. A broad spectrum of control also is imperative.

Vertebrate Pests in Sweet Corn

Table 72. Vertebrates that require annual management, based on input from 205 New England sweet corn growers

Rank	Vertebrate	Annual Management (# of growers)
1	Birds	102
2	Raccoons	87
3	Deer	54
4	Porcupine	9
5	Skunks	4
6	Coyote	4
7	Turkeys	4
8	Bears	5
9	Squirrels	5
10	Geese	3
11	Possums	1
12	Beaver	1

Table 73. Percentage of sweet corn acres infested with vertebrate pest based on input from participants at the Sweet Corn PMSP workshop

Vertebrate Pest	**% Acres Infested**						
	Grower						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Bird	100	50 (seedlings), 30 (harvest)			50	70	10
Deer	50	100			30		40
Raccoon	100	100			5		Very low
Coyote		30+					None
Other							Extremely low
Squirrel	40						
Porcupine	0						
Beaver	10	10					
Skunk	90	100					
Bear							
Woodchuck		25					

Table 74. Vertebrate pest management based on input from participants at the sweet corn PMSP workshop

Vertebrate Pest	Comments[1]
Birds	Best results when control is integrated, gave good control of vertebrate pest; turkeys a big problem (seedling emergence and harvest); shotgun management is outlawed in some heavily populated areas; some success with variety selection, variety confirmation (upright yields); some varieties have loose husk and poor tip cover by husk; Canada geese and starlings are main bird pests; not a problem for stand establishment; ≤10 percent acres affected at ear development
Deer	Encourage hunting
Coyotes	Acreage affected is increasing
Raccoons	Cyclical problem related to rabies incidence in an area
Other	Pests are present but no measurable economic damage; humans cut fences, vehicle damage to fences

[1]Grower comments are separated by semicolons. A comma indicates multiple comments by the same grower.

Table 75. Strategies used to manage birds, and their effectiveness, based on input from 146 New England sweet corn growers

Control Option	# Growers	% Growers	Excellent	Good	Poor
Scare-eye balloons	66	31	5	40	19
Chop and leave debris after harvest	38	18	2	25	11
Recorded distress call devices	28	13	4	12	12
Cannons	25	12	2	15	7
Shell crackers	20	9	2	10	8
Shooting	14	6	6	3	4
Avitrol bait	11	5	2	4	5
Hanging bird carcass	3	1	2	1	0
Dogs	1		0	1	0
Fake owl	1		0	1	0
Scarecrow	1		0	1	0
Netting	2	1	2	0	0
Treated seed	1		1	0	0

Table 76. Management methods for bird pests based on input from participants at the Sweet Corn PMSP workshop

Management Method	Grower Rating[1]
Avitrol bait	F
Seed treatments	1P, 1 G
Cannons	1N, 2P, 2G
Recorded distress, call devices	1N, 1P, 1F-G, 1G
Scare eye balloons	1N, 2P, 1F
Reflective ribbons	1N, 2P, 1P-F
Shell crackers	1N, 1G
Chop and leave debris after harvest	1N, 1P, 1F
Leave old corn standing	1N, 1P, 1F
Shotgun	1N, 2G, 1G-E
Dogs	1N, 1F
Other	G (topping)

[1]F, fair; E, excellent; G, good, N, not used. A number in front of a rating indicates the number of growers providing the information.

Table 77. Strategies used to manage deer, and their effectiveness, based on input from 124 New England sweet corn growers

Control Option	# Growers	% Growers	Excellent	Good	Poor
Hunting	58	27	12	25	19
electric fence	29	13	13	12	1
Dogs	16	7	6	5	5
Deer Away	8	4	0	2	6
Hinder	6	3	0	4	2
fence (non electric)	5	2	2	1	2
None	16	7			
Not a problem	7	3			

Table 78. Strategies used to manage raccoons, and their effectiveness, based on input from 152 New England sweet corn growers

Control Option	# Growers	% Growers	Excellent	Good	Poor
Trapping	90	42	23	50	16
Dogs	37	17	14	18	4
Electric fence	35	16	10	13	11
Shooting	7	3	2	2	1
Plant trap crop at edge	3	1	0	1	1

Table 79. Strategies used to manage other vertebrate pests, and their effectiveness, based on input from New England sweet corn growers

Pest and Strategy	# Growers	Excellent	Good	Poor
Skunk	13			
Trap	9	1	6	1
Electric fence	1	0	1	0
Shoot	1	1	0	0
Avoid plant near tree line	1	0	1	0
Bear	16			
Hunt/shoot	4	2	1	1
Dogs	3	1	2	0
Radio	3	0	2	1
Electric fence	2	2	0	0
Coyote alarm from USDA	2	0	0	2
None	3	0	0	1
Squirrel	8			
Trap	3	0	2	1
Dogs	1	0	0	1
Electric netting	1	0	1	0
Sharing	1	0	1	0
Porcupine	15			
Trap	6	2	3	0
Hunt/shoot	5	3	2	0
Plant more	1	0	0	1
Woodchuck	7			
Hunt/shoot	4	3	1	0
Coyote	2	2	0	0
Trap	1	0	1	0
Smoke bombs	1	0	1	0
Coyote	16			
Traps	2	2	0	0
Electric fence	1	0	0	0
Chase out	1	0	1	0
Shoot	1	0	0	1
Dog repellents	1	0	0	1
None	6			

Table 80. Management methods for mammalian pests based on input from participants at the Sweet Corn PMSP workshop

Management Method	Vertebrate Group and Management Rating[1]			
	Deer	Raccoon	Coyote	Other
Fence (nonelectric)	F-G, E			
Electric fence	2G	2G, E	E	E (beaver, woodchuck)
Hinder (spray repellent)	N, P, F			
Deer Away (spray repellent)	N, P			
Dogs	N, P	N, F		
Hunting	P, G			
Other repellents	N, P	N		
Trap crop at edge		N		
Trapping		G, E		F-G (bear, skunk)
Hunting		N, F		
Other		Rabies		Woodchuck bomb (not rated)

[1]F, fair; E, excellent; G, good, N, not used. A number in front of a rating indicates the number of growers providing the information.

Worker Activities in Sweet Corn Production

Planting

- Seeds treated with fungicides are used to prevent seed decay. Of the survey respondents, 56 percent used fungicide treated seed.

- Treated seeds are purchased from the seed supplier.

- Growers who do not wear protective gloves can be exposed to the fungicide on the seeds while doing common tasks during the process of planting, such as filling or cleaning out the hopper, or checking the seed in the soil for spacing and depth.

Scouting

- Scouting sweet corn for insect pests and damage is recommended and done on many farms to determine whether insect control is needed, and if so, when.

- Scouting in the field begins when the corn is knee-high and continues once per week through the silking period. Corn earworm traps are set up in fields before silking and are checked for moths one to two times per week.

  The potential for a significant exposure to pesticides is possible if a scout were to enter a field after a pesticide application. Early scouting in whorl, pretassel, and tassel stage corn involves touching many leaves. Corn earworm traps are monitored when the corn ears are silking and the corn has grown above head level. It is impossible to reach the trap without touching and being touched by the corn leaves.

Eighty-seven percent of survey respondents scout for insect pests on their farms. Although 68 percent of the growers scout themselves, many also use farm employees (16 percent), private IPM scouts, or consultants (11 percent), and university/extension scouts (12 percent).

When corn scouts are used, close communication with the pesticide applicator is necessary to ensure that scouting is done after the REI for any sprays that have been applied.

Hand weeding/hoeing

- Hand weeding (27 percent) and/or hoeing (20 percent) are done in young corn to reduce weed competition and help establish the crop.

- Workers who weed in the early corn may be exposed to postemergence herbicides. Likely exposure.

Pesticide applications

- Most growers achieve marketable sweet corn by spraying for the three main caterpillar pests: CEW (*Helicoverpa zea*), ECB (*Ostrinia nubilalis*), and FAW (*Spodoptera frugiperda*). respondents apply an average of four pesticide applications per year aimed at controlling insects, 1.15 sprays for weeds, and 0.135 applications for disease control.

- Sprays for FAW are generally applied when the corn is in the whorl stage, whereas ECB control is applied at the pretassel stage or early tassel stage. Usually, one or two sprays will control these pests at these plant growth stages. Control for corn earworm is applied during the silking stage, every 2–5 days until harvest, as needed depending upon pest pressure and temperature.

- Worker must mix sprays, clean equipment, and be on the tractor in the field during the application. Amount of contact with pesticide treated surfaces depends upon the care of the individual worker. Workers using a boom sprayer or air blast sprayer have limited exposure to pesticide treated corn, whereas those using a back pack sprayer must walk through the corn, and could potentially be exposed to high levels of pesticides. Of the New England growers responding to the survey, 18 percent apply pesticides at some time using a back-pack sprayer.

- Ninety-two percent of respondents use field IPM, read pest alerts to manage insects, or both: 32 percent use pheromone traps to monitor for corn earworm, 25 percent to monitor European corn borer, 20 percent to monitor fall armyworm; 81 percent field scout for caterpillars or feeding damage; and 60 percent read state or regional pest alerts.

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