

Benefits of Pyrethroids to Sweet Corn

PYRETHROIDS BENEFITS PROJECT

The Pyrethroid Working Group contracted an extensive analysis of the benefits of pyrethroids to agriculture. A multitude of data was analyzed with different methodologies to determine the value of pyrethroids, and the costs to farmers if they were no longer available. These analyses determined: (1) costs to the farmer of key insect pest management practices with and without pyrethroids, (2) Yield benefits of pyrethroids, (3) monetary and non-monetary value of pyrethroids based on a farmer survey, and (4) a multi-market analysis to project the aggregate economic benefits of pyrethroids to the U.S. economy. Below are the primary benefits of pyrethroids from these analyses.

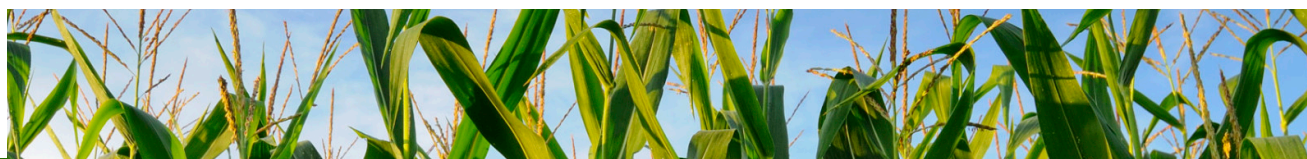
BENEFITS TO SWEET CORN

1. Costs with and without pyrethroids

- Total market value in the U.S. for fresh and processed sweet corn in 2015 was \$788 million and \$255 million, respectively.
- Of all the insecticide-treated acres in sweet corn, 60% are treated with pyrethroids.
- Sweet corn has 3.37 pyrethroid applications per acre on average, reflective of the need to meet the zero tolerance requirements for damage and contamination in fresh and processed sweet corn.
- Costs per acre, with and without pyrethroids, demonstrate the value of pyrethroids in sweet corn. Without pyrethroids, sweet corn farmers would see insecticide costs increase 64% per treated acre.
- Based on 2012-2014 numbers, with pyrethroid treatments averaging \$4.62/acre, costs would rise to an average \$12.94/acre without pyrethroids (64% increase), or \$8.32/acre.
- With almost \$9 million spent on pyrethroids in 2012-2014, costs to replace would be over \$25,000,000. The increased per acre costs of the non-pyrethroid scenario translate into an overall cost increase to the sweet corn industry of over \$16,000,000 (73%), to replace pyrethroid use.
- Loss of pyrethroids would result in cost increases reducing farmer profits and increasing the cost of sweet corn.

2. Yield Benefits

- The silk fly complex (FL), corn earworm (WA), and the complex of lepidopteran pests — corn earworm, European corn borer, fall armyworm and western bean cutworm (Upper Midwest), are the most economically important insect pest management challenge facing fresh sweet corn farmers.
- The pyrethroids are the only active ingredients with sufficient adult knockdown and persistence on silks to control all these pests and meet the zero tolerance requirements for damage and contamination in processed sweet corn.
- The ear-feeding lepidopteran pests (fall armyworm and corn earworm) cause severe economic damage in south Florida and to all other sweet corn production areas. There are no biological controls that can hold populations below damaging levels, and multiple spray programs are needed to produce damage-free corn. A wide range of active ingredients is needed to provide fast knockdown of adults to suppress egg laying and provide residual control on leaf surfaces to control larvae. Pyrethroids are the most effective in both adult and larval control and form the basis of management programs for most farmers.
- The results of 279 observations in small test plots show that foliar-applied pyrethroid insecticides are the most effective method for managing the multitude of sweet corn pests.



- For sweet corn, yield increases were 231%, and average reductions of pest populations were 81%, which reduced crop damage by 60%-65% when compared to untreated corn.
- Pyrethroids give a 12.5% advantage for reducing pest abundance, based on 89 observations.
- Pyrethroids give sweet corn a 16% yield benefit over other insecticides.
- The projected yield loss if pyrethroids were not used was 16% for sweet corn.
- Without pyrethroids, the loss of these yield gains could be the difference between making a profit or losing money for the farmer.
- Currently, pyrethroids are the only effective alternative to managing a new pest, the brown marmorated stink bug, which is emerging as a key concern for the region.

3. Monetary and Non-Monetary Value to Farmers (Case Studies)

Main insights from Florida fresh market sweet corn production

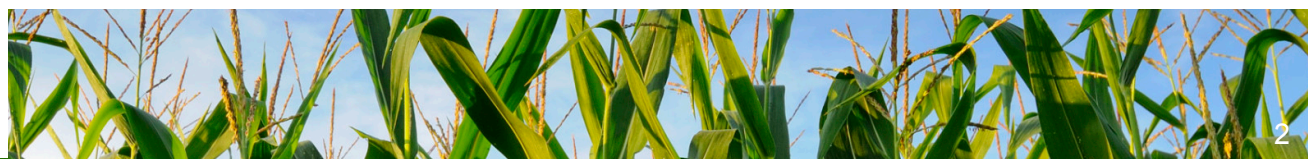
- The silk fly complex is the most economically important insect pest management challenge facing fresh sweet corn farmers in south Florida and currently, pyrethroids are the only effective treatment; multiple applications are required to produce damage-free sweet corn.
- For fresh market blemish-free sweet corn, farmers must manage the ear-feeding lepidopteran pests (fall armyworm and corn earworm); pyrethroids are the most effective materials in both adult and larval control of these pests.
- In Florida, soil inhabiting lepidopteran pests (lesser cornstalk borer and cutworm complex) need to be controlled; currently, the only effective active ingredients are pyrethroids and organophosphates.
- The conclusion from the case study with a major sweet corn and green bean farmer in the Lake Okeechobee area is that production of fresh, winter vegetables in south Florida, which supplies the eastern U.S., would not be possible without pyrethroid insecticides.

Main Insights on sweet corn in Washington and the Pacific Northwest

- The pyrethroids are the only active ingredients with sufficient adult knockdown and persistence on silks to control corn earworm and meet the zero tolerance requirements for damage and contamination in processed sweet corn.
- Pyrethroids meet the requirement for established MRLs in the export market.
- Currently, pyrethroids are the only effective alternative to managing a new pest — the brown marmorated stink bug, which is emerging as a key concern for the region.

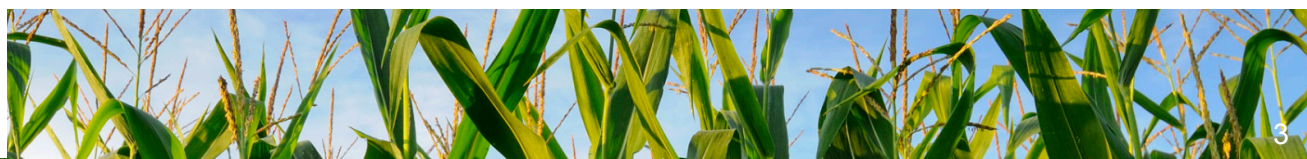
Main insights on sweet corn in Wisconsin and the Midwest

- Pyrethroids are the only materials that can provide sufficient adult knockdown and persistence on silk and leaf surfaces to control larvae of the complex of lepidopteran pests — corn earworm, European corn borer, fall armyworm and western bean cutworm — that must be managed to meet the zero tolerance for damage required by the industry.
- Use of pyrethroids in a pest management approach that targets applications to specific ‘treatment windows’ has proven very effective at achieving sufficient control with only 1-3 applications while other active ingredients often require 4-6 applications to achieve comparable control.
- In Wisconsin and the Midwest, pyrethroids are also essential in the management of other pests in the complex — including corn rootworm adults, corn leaf aphid and potential new threats, such as the brown marmorated stink bug. These pests are currently controlled effectively by pyrethroid regimes targeting lepidopteran pests.



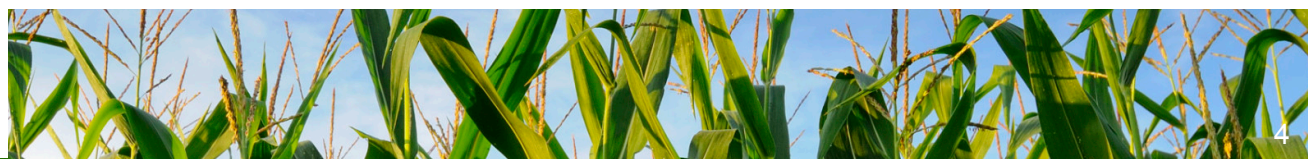
4. Direct and Indirect impacts

- The economic benefit for society from using pyrethroids on a per cropped acre basis is \$365/A for sweet corn
- For specialty crops, the estimated net economic benefit is \$784 million annually, of which \$210 million is for sweet corn
- The cost impacts if pyrethroids were no longer available were an increase of \$28 per cropped acre for sweet corn
- Resistance management is a key concern for sweet corn pests with only 4 modes of action available.
- Pyrethroids already meet the requirement for established MRLs in the export market.
- For fresh market blemish-free sweet corn, farmers must manage the ear-feeding lepidopteran pests (fall armyworm and corn earworm); pyrethroids are the most effective materials in both adult and larval control of these pests.
- Sweet corn varieties that have been genetically modified to express *Bt* endotoxins provide excellent control of corn earworm with no insecticide applications, but this technology cannot be used by processors due to export to countries that do not accept GMO technology. Processing companies must also take stringent precautions to make sure that sweet corn fields are isolated from potential contamination from GMO field corn.
- To meet the zero tolerance requirements for damage and contamination in processed sweet corn, an insecticide used for earworm control must have strong activity against adult moths entering fields to reduce egg laying, and good persistence on plant surfaces to kill small larvae on ear silk before they enter ears. The pyrethroids, particularly the 3rd generation pyrethroids, are the only active ingredients with these characteristics and are widely relied on by the industry.
- Using a pest management approach that limits application to periods when plants are susceptible to damage and when key pests are in sufficient abundance to cause damage has enabled processors to reduce treatment regimens from 4-6 applications a decade ago to 1-3 applications currently.



Insect Pests of Florida Fresh Market Sweet Corn

Pests	When controls are applied	Importance of pyrethroids	Resistance Concerns	Alternative management strategies	Potential impacts of pyrethroid loss
Key Pests					
Lepidopteran complex: fall armyworm, corn earworm	Row tassel to harvest	Only options providing adult knockdown and persistence on plant to protect ears	Multiple sprays used –resistance anticipated, use pyrethroids in rotation with other MoAs to manage resistance	None	Increased ear damage, severe economic loss
Soil lepidopteran complex: lesser cornstalk borer, cutworms	Germination and early plant growth	Safe and effective as soil or banded applications	None	Organophosphate and carbamate soil applications	Reduced plant stand, lower yields, increased environmental risk
Corn silk fly	Silking	Continual re-infestation requires multiple applications. Pyrethroids are only option with adult knockdown and larval control and are primary tools	Resistance to pyrethroids documented, AIs with different MoAs needed in rotations to manage resistance, potential for synergists to extend efficacy	Carbamates, organophosphates and other AIs are available but less effective	Could not produce winter sweet corn in FL, increased worker safety and environmental risk
Sporadic Pests					
Rootworm and cucumber beetle adults	Row tassel through brown silk	Pyrethroids used for ear protection prevent silk pruning	Lepidopteran resistance management	None	Reduced ear fill, lower quality
Aphids	Tassel emergence	AIs used for silk worm also control aphids	None	None	Reduced pollination and ear fill



Insect Pests of Washington Sweet Corn

Key Pests					
Corn earworm	Row tassel to brown silk	A range of AIs with differing MoAs available, pyrethroids the only AIs that have sufficient adult knockdown and surface persistence to prevent ear damage	Not reported in earworm but alternative MoAs registered if needed	None	Substantial increase in sprays, increased resistance, crop rejection
Sporadic Pests					
Seed corn maggot	Seed	Neonicotinoid seed treatment	None	Cultural (partial), alternative AIs, organophosphates	Increased environmental risk if neonicotinoids restricted
Cutworms and armyworms	Emergence to early plant growth	Soil or banded applications	None	Alternative AIs, organophosphates, carbamates	Increased environmental risk
Corn rootworm adults	Silking	Pyrethroids for ear protection, control silk pruning	None	None	Reduced pollination and ear fill

Insect Pests of Wisconsin Sweet Corn

Key Pests					
Lepidopteran complex attacking ears: corn earworm, European corn borer, fall army worm, western bean cutworm	Row tassel through brown silk	Sole options to provide adult control and enough persistence to kill larvae prior to ear damage. Pyrethroids used extensively	None except earworm migrating from the south, alternative MoAs available if needed	None other than use of alternative AIs which are less effective	Severe yield loss, processor rejection Reversion to alternate AIs would result on more sprays, reduced efficacy, greater worker safety and environmental risk
Sporadic Pests					
Seed corn maggot	Seed	Neonicotinoid seed treatment	None	Cultural (partial), organophosphate soil applications	Increased worker and environmental risk
Cutworms, true armyworm	Seedling, early plant growth	Soil or banded pyrethroids	None	Organophosphates and carbamate soil treatments	Increased worker and environmental risk
Corn rootworm adults	Silking	Pyrethroids used for ear protection prevent silk pruning	None	None	Greater use of alternative AIs, more damage, less ear fill

