Midwest Pest Management Strategic Plan for Processing & Jack-o-Lantern Pumpkins

Illinois, Indiana, Iowa and Missouri

Workshop Summary
March 17-18, 2005
Urbana, Illinois

Sponsored by:
USDA North Central Region IPM Center

Hosted by:
University of Illinois Extension

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Contents

INTRODUCTION

THE PUMPKIN PEST MANAGEMENT STRATEGIC PLAN PROCESS

Producers, processor representatives, university specialists, and USDA and EPA representatives met in Urbana, Illinois for one and a half days to review, determine and summarize the critical needs of the jack-o-lantern and processing pumpkin industry in Illinois, Indiana, Iowa, and Missouri. In order to maximize interaction and emerge with a more integrated Pest Management Strategic Plan (PMSP), the group remained together throughout the entire meeting rather than splitting into discipline-focused groups. As a starting point, the various field activities were discussed and timelines were documented. The major disease, insect, weed and vertebrate pests were reviewed and discussed and pest-specific research, regulatory and educational action items were determined. The efficacy and pros and cons of existing and potential pest management tools and practices were discussed and evaluated. Finally, using democratic means, a set of overall research, regulatory and educational priorities were established.

BENEFITS TO THE PUMPKIN INDUSTRY

A multi-state PMSP goes well beyond the information provided in a traditional Crop Profile. Most notably, the PMSP is a forward-looking document which draws upon the diverse experience and expertise of a wide range of individuals. Successful PMSP workshops essentially compel the participants to recognize and reconcile the minor and major factors which limit their commodity. Finally, the PMSP provides published documentation which addresses a wide variety of stakeholder needs such as:

<u>Producers</u>

- Priorities for research, education or other sponsored programs.
- Useful document for conveying needs to policy makers.
- Documentation to support Section 18 & 24(c) requests.

<u>Researchers</u>

- Documentation of stakeholder needs; supports funding requests.
- Support for IR-4 Food Use Workshop research prioritization.

<u>Regulators</u>

- Receive information on actual pest management practices and timelines; less likely to use default assumptions in risk assessments.
- Made aware of special concerns (e.g., resistance management)

<u>Registrants</u>

- May identify markets for development of new products.

BACKGROUND: PUMPKIN PRODUCTION

The Cucurbitaceae family is diverse, including vine crops such as pumpkins, squash, gourds, cucumbers, and melons. The four species listed below include the "pumpkins", which are all warm season annuals:

- *Cucurbita maxima* Dutch.: winter squash, giant pumpkin
- *Cucurbita mixta* Pang.: pumpkin
- *Cucurbita moschata* Poir.: winter squash, processing pumpkin
- *Cucurbita pepo* L.: winter squash, marrow, summer squash, pumpkin

Although the pumpkin species listed above are similar in growth and culture, there is considerable diversity in fruit size, color, and texture. As alluded to in the species descriptions above, there is so much diversity that some of the varieties may not be recognized as pumpkins. In fact, some publications, including some pesticide labels, refer to pumpkins as "winter squash" or "summer squash". By definition, summer squash is harvested when the rind is soft and the fruit is immature, whereas winter squash is harvested when the rind is hard and the fruit is mature.

Although much of the information provided in this publication would be applicable to summer squash and other vine crops, the focus is on jack-o-lantern and processing pumpkins.

According to the most recent Census of Agriculture data (see Table 1), in 2002 Illinois, Indiana, Iowa, and Missouri contributed approximately 20% of the nation's jack-o-lantern pumpkins and 59% of the nation's processing pumpkins. According to this same report, Illinois ranked first in the number of jack-o-lantern pumpkin acres harvested and acres harvested for processing.

Table 1. Pumpkin farms and acres in Illinois, Indiana, Iowa, and Missouri in 1997 and 2002.

Area	2002				1997 Harvested	
	Harvested		Harvested for Processing			
	Farms	Acres	Farms	Acres	Farms	Acres
Illinois	475	12,296	90	8,181	492	7,783
Indiana	495	4,242	5	155	462	2,929
Iowa	263	860	21	53	218	728
Missouri	301	1,697	33	(D)	278	1,700
Region Total	**1,534 (11%)**	**19,095 (20%)**	**149 (18%)**	**>8,389 (59%)**	**1,450 (12%)**	**13,140 (16%)**
US Total	**14,073**	**97,408**	**815**	**14,179**	**11,723**	**79,707**

Source: National Agriculture Statistics Service. 2002 Census of Agriculture, Volume 1 Chapter 2: U.S. State Level Data (Table 29). http://www.nass.usda.gov/census/census02/volume1/us/index2.htm
D = Withheld to avoid disclosing data for individual farms.

Variety selection

As shown in Appendix 2, there are 56 pumpkin varieties available and considered to be widely grown. Most of the varieties (43) are classified as miniature, small, medium and large pumpkins. The remaining 13 varieties are classified as very large (mammoth), specialty, hull-less, or processing types. Among all varieties listed, the only disease resistance traits available are tolerance to powdery mildew and zucchini yellow mosaic virus (ZYMV).

Tillage systems

As shown in Appendix 1a and 1b, spring and fall primary tillage, inter-row cultivation, and hand hoeing are used during the same time-frames for both jack-o-lantern and processing pumpkins. Because soil fumigants are quite expensive and difficult to obtain, soil fumigation is not used in pumpkin production.

Planting

Pumpkins are a warm season crop, susceptible to frost damage. Thus, pumpkins should be planted after the date of the last spring frost. Planting too early when soils are too cold and wet will result in poor seedling emergence. The optimum soil temperature range for proper germination is 68-75°F. When soil temperatures are 60°F and below, pumpkin seeds will not germinate.

All processing pumpkins are direct-seeded. The use of transplanting and mulch is used by few Illinois, Indiana, and Missouri jack-o-lantern growers. However, it is estimated that this practice is used on nearly one third of the jack-o-lantern pumpkin acres in Iowa. Due to the weed-suppression advantage of transplanting into mulch, organic producers may use this practice more than conventional growers. It is relatively difficult to transplant vine crops and some have observed increased rodent problems in transplanted crops.

Recommended direct-seeding instructions include a seeding rate of 2 to 3 pounds per acre and a planting depth of one inch. Jack-o-lantern pumpkins are generally seeded in single rows, with the rows planted 6 to 8 feet apart. However, processing pumpkins are planted in double-row fashion. Individual plants in each row are seeded 2 to 5 feet apart.

Fertilizing

Preplant fertilizer recommendations are as follows. To maintain a soil pH of 6.0 to 6.8, an application of lime may be required. Apply 50 pounds of nitrogen per acre, 0 to 150 pounds of P_2O_5 per acre, and 0 to 200 pounds of K_2O per acre. Adjust according to soil type, previous management, and soil test results by state. For soils with more than 3% organic matter and following soybeans, alfalfa, or a grass-legume hay crop, no nitrogen is needed. For soils with less than 3% organic matter along with the above crop rotations, or a rotation of corn, rye, oats, wheat, or a vegetable crop, apply 30 to 40 pounds of nitrogen per acre when the vines begin to run. For sandy soils, the preplant nitrogen application can be replaced by an early sidedressing of 40 pounds of nitrogen per acre when the plants show the first set of true leaves. Then, the second sidedress

application of 45 pounds of nitrogen per acre should be carried out at the onset of rapid vining. However, from discussions during the March workshop, it is clear that the practice of sidedressing fertilizer is not used by processing and jack-o-lantern pumpkin growers.

Irrigation

Irrigation practices vary considerably by region, operation size, and types of pumpkins being produced. For processing pumpkins, it was estimated that 50% of the acreage is irrigated through center pivot irrigation. For jack-o-lantern pumpkins, about 20% of the Iowa producers utilize center pivot irrigation. In Indiana, it was reported that some of the smaller operations utilize solid set and center pivot irrigation.

Pest management

Pumpkins like most vegetable crops, compete with weeds and are attacked by a variety of insect and disease pests. Producers utilize a number of different management strategies to control pumpkin pests, such as crop rotation, irrigation, planting date, scouting, variety selection, cultivation, mulch, tillage, and pesticides.

In order to quantify the extent to which processing and jack-o-lantern pumpkin producers utilized different pest management strategies in Illinois, Indiana, Iowa, and Missouri, a survey was conducted following the 2002 growing season (Gerber C., R. Foster, *et. al*.). The results of this survey are provided below and in Tables 1 through 3.

Table 1. Non-chemical management strategies used by pumpkin producers[1] located in Illinois, Indiana, Iowa, and Missouri.

Pest group	Management strategy	Producers utilizing[2]	Acreage impacted[3]
Diseases	Crop rotation	**91%**	**96% (2,541.42 A)**
	Irrigation	7%	0.72% (19.01 A)
	Planting date	38%	**58% (1,524.75 A)**
	Scouting	**63%**	**77% (2,023.65 A)**
	Variety selection	**58%**	**63% (1,653.67 A)**
Insects	Crop rotation	**75%**	**90% (2,367.18 A)**
	Irrigation	4%	0.086% (2.26 A)
	Planting date	34%	39% (1,027.96 A)
	Scouting	**71%**	**81% (2,148.82 A)**
	Variety selection	33%	19% (498 A)
Weeds	Crop rotation	**72%**	**86% (2,286.67 A)**
	Cultivation	**85%**	**93% (2,451.03 A)**
	Hand-weeding	**75%**	**74% (1,962.26 A)**
	Irrigation	7%	0.89% (23.46 A)
	Mulch	11%	2% (54.6 A)
	Planting date	37%	**57% (1,503.7 A)**
	Scouting	**52%**	**68% (1,791.35 A)**

	Tillage	**75%**	**80% (2,109.43 A)**
	Variety selection	15%	13% (345.2 A)

[1] 137 pumpkin producers from Illinois, Indiana, Iowa, and Missouri responded to this survey.
[2] Percent of responding pumpkin producers that utilize the specified non-chemical management strategy.
[3] Percent of acres that utilize the specified non-chemical management strategy.

Table 2. 2002 pumpkin acreage rotated to non-cucurbit crops for 2, 3, or 4 years prior to pumpkin production.

Years	Acreage	Percent [1]
2	435 A	17%
3	533 A	20%
4	1,183 A	45%

[1] This column does not total 100%; some of the acres were either not reported or the rotation practices did not match the three possible answers of 2, 3, or 4 years.

As shown in Table 1, a majority of the producers use crop rotation and scouting to manage diseases, insects and weeds. However, as shown in Table 2, 17% of the pumpkin acreage is rotated in such a way that it is insufficient to slow or prevent the build-up of common diseases such as Phytophthora blight and Plectosporium blight (see Appendix 3). A slim majority of producers utilize variety selection as a means to manage disease (presumably varieties tolerant to powdery mildew; see Appendix 2). In terms of non-chemical weed control strategies, most producers also utilize tillage, cultivation, and hand-weeding (hoeing).

When one considers the percentage of acres (Table 1) impacted by these management activities, the outcome is the same except that planting date now appears to be a practice used to manage diseases and weeds on a small majority of acres.

Table 3. Percent yield loss estimated by pumpkin producers[1] (Illinois, Indiana, Iowa, and Missouri) if pesticides were not available.

	Percent yield loss if pesticides are unavailable			
Pesticides	**0-25%**	**26-50%**	**51-75%**	**76-100%**
Fungicides	29%[2]	26%	33%	13%
Insecticides	15%	23%	33%	29%
Herbicides	31%	31%	25%	14%

[1] 137 pumpkin producers from Illinois, Indiana, Iowa, and Missouri responded to this survey.
2 Percent of surveyed pumpkin producers (Illinois, Indiana, Iowa, and Missouri) estimating a certain percent of yield loss if pesticides were not available.

As shown in Table 3, most producers feel that insects pose the biggest threat to yield if pesticides were not available. Using the same criteria, diseases ranked second and weeds third. From these results, as well as from discussions during the March workshop, it is clear that pumpkin producers rely upon fungicides, insecticides, and

herbicides to control pumpkin pests. No specific estimates were provided, but meeting participants indicated that a significant percentage of foliar insecticides and fungicides are applied by aircraft.

Meeting participants estimated the percentage of organically-produced pumpkin acreage to be very low. Why are pesticides so important in pumpkin production? As detailed in Appendices 3 through 5, there are relatively few non-chemical control tactics rated as "important tools". Research, regulatory, and educational priorities for strengthening non-chemical control tactics are outlined in the "Pumpkin Industry Priorities" section of this document.

Harvest and Storage

Depending on variety, planting date and the growing season, jack-o-lantern pumpkins are harvested from mid-August through late October. Processing pumpkin harvest may begin 1 to 2 weeks earlier. Processing pumpkins are harvested only by mechanical means, whereas jack-o-lantern pumpkins are usually hand-harvested to avoid fruit damage.

In order to "cure" pumpkins prior to storage, they should be held at 85-90°F and 80% relative humidity for four days. Following the curing process, pumpkins should be stored at 55°F where they will last for several months, depending on the variety.

PUMPKIN INDUSTRY PRIORITIES

The March meeting was concluded by determining the overall industry priorities. All participants (except researchers) submitted their research, regulatory, and education priorities. In a few cases, researchers submitted priorities that were given to them by absent growers. As a group, we consolidated similar priorities. Within each section (research, regulatory, and education), all participants were allowed to vote for three priorities. Using the results of this poll, the top 3 to 6 priorities in each section were determined and placed in numerical order. Suggested priorities that did not receive sufficient votes in the final poll are also included below as bulleted points.

Research priorities:

1. Phytophthora biology and management.
2. Predictive forecasts to help guide disease and insect management strategies.
3. Virus identification, management and resistant varieties. Better understanding of cucurbit/virus/vector complexes.
4. The need for post-emerge, selective, broadcast, broadleaf & grass herbicides that work. Especially for problem weeds such as black nightshade and new weeds, such as kochia and waterhemp.
5. Bacterial spot: How do we get on top of this problem? Need crop rotation guidelines.
6. Efficacy trials to evaluate new pesticides.

- Vines are sometimes too vigorous. When might fungicides or other inputs hurt yield or quality (i.e., excess vine, greener fruit). Fertilization techniques (e.g., split applications of nitrogen) for bush vs. vining types to increase yield.
- Develop resistant varieties (including GMO) to cope with insect and disease problems. Evaluate existing and new varieties for susceptibility, pest preference, and marketability.
- Production of clean fruit by jack-o-lantern producers. Spring seeding of cover crop followed by knockdown (by glyphosate or by mechanical rolling) for early-June seeding. Weed control and clean fruit are the objectives.
- Relationship between cultural practices and insect and disease development.
- Need for seed treatment insecticides and fungicides to protect plant for first six weeks of life. Investigate the use of herbicide safener treatments.
- Effective pest management via chemical, non-chemical and biological methods.
- Obtain funding from private sector; reduce reliance on government funding.
- Management of vertebrate pests.

Regulatory priorities:

1. Need new pesticides with different modes of action. Increase speed of bringing chemicals into the market place. Increase support for IR-4 program. How can chemical companies be moved to develop new products? Latitude for larger trials for pipeline products in different areas (chemical and biological).
2. Desire that the following herbicides include pumpkins on their labels: Dual Magnum, Outlook and Raptor.
3. Relaxation of fruit & vegetable restrictions with existing Farm Bill.
4. Development of protocol for bacterial spot on seed. Mandate testing on seed for bacterial spot.
5. Need seed treatment insecticides and fungicides. Allow seed treatments for cucumber beetle.

- Maintain carbamate (carbofuran and maneb) registrations; these are highly effective and inexpensive for the farmer.
- Safer, more people-friendly chemicals.
- Relaxation of rotational restrictions on chemicals used prior to growing pumpkins.
- Encourage label language to reduce incidence of resistance to pesticides (e.g., reduce number of back-to-back sprays for high risk products)
- Desire Roundup-Ready Magic Lantern as well as other pumpkin varieties.

Educational priorities:

1. Educate growers regarding disease and insect scouting, identification, life cycles and prediction/forecasting. Using tracking systems to identify practical spray schedules. Downy mildew prediction. Best management for bacterial spot. How to use traps for squash vine borer detection (i.e. to be able to apply two sprays instead of 3 or more sprays at weekly intervals).
2. Communication (via newsletter or website) about what works where and for whom, updates on new pesticides, variety updates (pest preference), tell us about informational websites.
3. Crop rotation advantages, prior crop rotation and residual concerns for crops.
4. Weed hosts of Phytophthora and viruses; how to manage based on current knowledge.
5. A “minimal”, but effective, season-long spray guide for insects/diseases.

- Sprayer and spray efficacy.
- Integration of cover crop/herbicide systems.
- Cost analysis of pumpkin production. More information on pricing of pesticide products.
- Educate public of the benefits of GMO pest control.
- Influence the development of new pesticide chemistries as needed.
- Sanitation of equipment to prevent spread of disease.

STRATEGIC ISSUES FOR PUMPKIN PESTS

DISEASES

Anthracnose

Four-state rank: 2B (Intermediate occurrence and intermediate ability to control)

Anthracnose, caused by the fungus *Colletotrichum orbiculare*, is an important disease of cucumber, muskmelon, and watermelon in the Midwest. Pumpkin and squash are less susceptible. This disease causes significant yield losses when conditions are favorable for disease development.

Symptoms. All parts of foliage, stems, and fruit can become infected. Symptoms of anthracnose include lesions which are roughly circular, light brown to reddish, and can reach ½-inch in diameter. The leaves may be distorted, and the center of the lesions may crack or drop out, creating a shot-holed appearance. On petioles and stems, lesions are shallow, elongated tan areas. On fruit, lesions are circular, sunken, water-soaked areas which first develop as the fruit approaches maturity. Under moist conditions, these lesions turn black and are covered with pink spore masses.

Disease Cycle. The pathogen survives between crops on infected plant residue or infected volunteer plants and can be carried on seed harvested from infected fruit. Conidia (spores) are produced and disseminated primarily by splashing water, and to a lesser extent by wind, and on people and machinery. Spore germination and growth are optimum at 72- 81°F (22-27°C) and 100% relative humidity for 24 hours. Visible symptoms appear about 96 hours after infection. Several races of the anthracnose pathogen, which vary in virulence on cucurbit hosts, are known.

Non-Chemical Control

- Anthracnose is difficult to manage once it becomes established in the field, thus practices should be employed to prevent contamination of a clean field.
- Since the pathogen is a seed-borne fungus, planting should be initiated with pathogen-free seed.
- Deep plowing of crop residue immediately upon completion of the harvest effectively reduces the inoculum level and should be combined with a crop rotation schedule in which no cucurbits of any kind are grown for at lease one year.
- Overhead irrigation should be avoided or minimized. Also, working in wet fields should be avoided.

Chemical Control

- Registered active ingredients rated as "Good" in Appendix 3:
  - Fungicide Resistance Action Committee (FRAC) Group 1: thiophanate-methyl (Topsin 70 WSB)
  - FRAC 11: azoxystrobin (Amistar, Heritage, Quadris F), pyraclostrobin (Cabrio EG)
  - FRAC 7, 11: boscalid + pyraclostrobin (Pristine)
  - FRAC 11, M5: azoxystrobin + chlorothalonil (Quadris Opti)
  - FRAC M5: chlorothalonil (Bravo, Echo, Equus)
- Registered active ingredients rated as "Good-Fair" or "Fair" in Appendix 3:
  - FRAC 27, 11: cymoxanil + famoxadone (Tanos)
  - FRAC M3: maneb (Maneb 75 DF, Manex)
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" in Appendix 3:
  - None.

Action items

Research needs:

- Determine the occurrence of the disease and the races. Fungicide efficacy.
- Determine what other hosts sustain the pathogen.

Regulatory needs:

- No comments.

Education needs:

- No comments.

Damping-off fungi

Four-state rank: 1C (Common occurrence and easy to control)

Damping-off may be caused by a number of soilborne fungi including *Fusarium*, *Phytophthora*, *Pythium* and *Rhizoctonia*.

Symptoms.

In preemergence damping-off, seeds may rot and seedlings may decay before they emerge. Young plants that do emerge may pale, curl, wilt, and collapse from a rot at or below the soil line (postemergence damping-off). The base of the stem is generally water-soaked at first, then turns gray to brown or black, and then rots. Seedlings are girdled by brown or black sunken cankers and these plants may shrivel and become dark and woody, causing wirestem or collar rot, but they do not normally collapse. Transplants grow slowly or die.

Disease Cycle.

Damping-off is more common under cold and wet soil conditions that are unfavorable for rapid seed germination and growth. The fungi that cause damping-off are able to survive in the soil for many years.

Non-Chemical Control

- Buy the highest-quality seed of recommended varieties.
- Plant in a light, well-drained, well-prepared, fertile seedbed at the time recommended for your area.

Chemical Control

- Most seed companies provide pretreated seed. Check the seed package to determine the kind of seed treatment used. If no seed treatment was applied, then use a chemical seed treatment. All processing pumpkin seed is treated with apron and captan, which provides much improved stands. For jack-o-lantern pumpkin seed, the grower decides whether the seed is treated with thiram or captan.
- Use an insecticide to control root aphids, grubs, wireworms, ants, maggots, cutworms, and webworms, all of which injure underground plant parts, allowing soil-borne organisms to enter and produce decay.
- Registered active ingredients rated as "Good" in Appendix 3:
    - FRAC 4: mefenoxam (Apron XL LS, Ridomil, Ultra Flourish)
    - FRAC 12: fludioxonil (Maxim 4FS)
    - FRAC M4: captan (Captan)
    - FRAC M5, 4: chlorothalonil + mefenoxam (Ridomil Gold Bravo)
- Registered active ingredients rated as "Good-Fair" or "Fair" in Appendix 3:
    - FRAC 11: azoxystrobin (Amistar, Heritage, Quadris F)
    - FRAC 27, 11: cymoxanil + famoxadone (Tanos)
    - FRAC M3: thiram (42-S Thiram)
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" in Appendix 3:
    - None.

Action items

Research needs:

- No comments.

Regulatory needs:

- No comments.

Education needs:

- No comments.

Downy Mildew

Four-state rank: 1A (Common occurrence and difficult to control)

Downy mildew, caused by *Pseudoperonospora cubensis*, affects all cucurbit crops. In Illinois, this disease usually occurs toward the end of the season.

Symptoms. Downy mildew only affects leaves. Symptoms of downy mildew vary with the host and the environmental conditions. The first symptom is usually the appearance of indistinct, pale green areas on the upper leaf surface. The pale green areas soon become yellow in color and angular to irregular in shape, bounded by the leaf veins. As the disease progresses the lesions may remain yellow or become brown and necrotic. During moist weather conditions, the corresponding lower leaf surface is covered with a downy, pale gray to purple mildew.

Disease Cycle. Downy mildew pathogen survives only on cucurbit hosts. The pathogen overwinters in the southern United States where cucurbits are grown during the winter. It progresses northward with cucurbit production each spring. Usually by the time downy mildew becomes established in the Midwest, it is toward the end of the season for most of the cucurbit crops. Once infection has taken place, the pathogen can produce spores (sporangia) in about four days, which initiate another infection cycle. Downy mildew is favored by cool, wet conditions.

Non-Chemical Control

- Early plantings for crops for July harvest often escape infection with downy mildew, while plantings for harvest in August or later in the season are vulnerable.
- Fields should be scouted regularly for disease development. A disease-forecasting program is available (www.ces.ncsu.edu/depts/pp/cucurbit).

Chemical Control

- Because of the potential for rapid plant infection, sprays should be initiated on a preventive basis for vulnerable plantings. When downy mildew is present, fungicides with curative activity tend to be more effective than protectants.
- Using curative fungicides with protectants will minimize resistance development in the pathogen.
- Registered active ingredients rated as “Good” in Appendix 3:
    - FRAC 4: mefenoxam (Apron XL LS, Ridomil, Ultra Flourish)
    - FRAC 7, 11: boscalid + pyraclostrobin (Pristine)
    - FRAC 11: azoxystrobin (Amistar, Heritage, Quadris F), fenamidone (Reason 500 SC), pyraclostrobin (Cabrio EG), trifloxystrobin (Flint)
    - FRAC 11, M5: azoxystrobin + chlorothalonil (Quadris Opti)
    - FRAC 15: dimethomorph (Acrobat)
    - FRAC 27: cymoxanil (Curzate 60DF)
    - FRAC 27, 11: cymoxanil + famoxadone (Tanos)
    - FRAC 28: propamocarb hydrochloride (Previcur Flex)
    - FRAC M5, 4: chlorothalonil + mefenoxam (Ridomil Gold Bravo)
- Registered active ingredients rated as “Good-Fair” or “Fair” in Appendix 3:
    - FRAC 33: fosetyl-AL, phosphorous acid, potassium phosphite (Aliette WDG, Agriphos, Fosphite, Phostrol, Prophyt)
    - FRAC M1: copper (Tenn-Cop, Champ, Kocide, KOP)
    - FRAC M3: maneb (Maneb 75 DF, Manex)
    - FRAC M5: chlorothalonil (Bravo, Echo, Equus)

- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" in Appendix 3:
    - FRAC 21: cyazofamid

Action items

Research needs:

- Investigate heat-unit based prediction system used by Tom Laatsch at Nestle. Can it be modified to include moisture, etc.?
- The pathogen seems to "act differently" from year to year; is this all due to environmental conditions?

Regulatory needs:

- No comments.

Education needs:

- This disease would be much easier to control if the fungicides were applied preventative. When to spray? Are most growers aware of the NCSU tracking web site?
- NCSU web site funding inconsistency – need to educate source(s) of funding about the value of this information.
- This disease is not controlled by some of our broad-spectrum fungicides.

Fusarium Crown and Fruit Rot

Four-state rank: 2A (Intermediate occurrence and difficult ability to control)

Fusarium crown and fruit rot, caused by the fungus *Fusarium solani* f. sp*. cucurbitae*, is a soil-borne disease. The disease occurs in the Midwest every year, but crop losses are usually limited.

Symptoms. Initial symptoms in the field include a yellowing of the leaves, which is followed by wilting of the plants. Eventually the entire plant dies. A close inspection of the base of the affected plant will reveal a water-soaked, dark brown rot of the crown and upper portion of the taproot. Often the stem is covered with a white to pink color of fungal growth (mycelium). Fruit symptoms may be small, dry, and pitted lesions, or larger sunken areas covered with gray or white mold. Fruit are usually attacked on the side in contact with the soil surface.

Disease Cycle. The fungus is a soil-borne pathogen and survives in soil for 2-3 years. This pathogen also can be internally or externally seed-borne. Two races of this fungus have been reported. Race 1 causes root, stem, and fruit rot and race 2 causes only fruit rot. The pathogen spreads with soil by mechanical means.

Non-Chemical Control

- Crown and fruit rot pathogen survives in the soil for only 2-3 years. Thus, a four-year rotation is usually adequate for control of this disease.
- Planting clean seed is highly recommended.

Chemical Control

- Fungicide seed treatment would reduce external inoculum of pathogen on seed.
- Registered active ingredients rated as “Good” in Appendix 3:
    - None
- Registered active ingredients rated as “Good-Fair” or “Fair” in Appendix 3:
    - None
- “Pipeline” active ingredients rated as “Good”, “Good-Fair” or “Fair” in Appendix 3:
    - None

Action items

Research needs:

- Interaction between this and other diseases of pumpkin.

Regulatory needs:

- No comments.

Education needs:

- No comments.

Black Rot

Four-state rank: 2B (Intermediate occurrence and intermediate ability to control)

Black rot is caused by the fungus *Didymella bryoniae*. This disease is known as gummy stem blight when it attacks the foliage and stems, and is known as black rot when it attacks fruit. The pathogen infects all cucurbit crops.

Symptoms. Circular, tan to dark brown lesions appear on the leaves, often first at the margins, and enlarge rapidly until the entire leaf is blighted. Circular, black or tan spots appear on the cotyledons and stems of young plants. Stem cankers develop in the cortical tissue, and a brown, gummy exudate is commonly produced on the surface. Small fruiting bodies (pycnidia or perithecia) may appear as black specks on the cankers. Stems may be girdled and seedlings killed.

The pathogen causes water-soaked lesions on fruit that can become a problem in storage. Gummy exudates may develop within these lesions. On most cucurbits, black rot symptoms appear as water-soaked areas that later become sunken and black in color. On butternut squash, the fungus causes a large area of superficial bronzing with distinct center rings.

Disease Cycle. The pathogen survives between seasons on crop debris and may be seed-borne. Infection by the fungus can occur at any stage of plant growth. Moisture is important for disease development. Fruit penetration by the fungus is either direct,

through wounds, or through flower scars at pollination. Fruit rot begins to develop about three days after infection.

Non-Chemical Control

- Seed should be pathogen-free.
- A two-year rotation out of cucurbits is essential.
- Crop residue should be plowed deeply as soon as the crop is harvested to reduce survival of the fungus.

Chemical Control

- Fungicide applications are needed where gummy stem blight is a problem.
- Fungicides with eradicant activity can be highly effective but are more at risk for development of pathogen resistance. Isolates of *D. bryoniae* resistant to benzimidazole fungicides (benomyl and thiophanate-methyl) or strobilurin fungicides (azoxystrobin) have been detected in cucurbits in the eastern United States.
- Registered active ingredients rated as “Good” in Appendix 3:
    - FRAC 11: azoxystrobin (Amistar, Heritage, Quadris F), pyraclostrobin (Cabrio EG)
    - FRAC 11, M5: azoxystrobin + chlorothalonil (Quadris Opti)
    - FRAC 7, 11: boscalid + pyraclostrobin (Pristine)
    - FRAC M3: maneb (Maneb 75 DF, Manex)
    - FRAC M5: chlorothalonil (Bravo, Echo, Equus)
- Registered active ingredients rated as “Good-Fair” or “Fair” in Appendix 3:
    - FRAC 1: thiophanate-methyl (Topsin 70 WSB)
- “Pipeline” active ingredients rated as “Good”, “Good-Fair” or “Fair” in Appendix 3:
    - None

Action items

Research needs:

- No comments.

Regulatory needs:

- No comments.

Education needs:

- Don’t save seed.

Phytophthora Blight

Four-state rank: 1A (Common occurrence and difficult to control)

Phytophthora blight, caused by *Phytophthora capsici*, is one of the most serious diseases of cucurbits. This pathogen also infects eggplants, peppers, tomatoes, and more than 40 other crop and weed species.

Symptoms. Infection usually appears first in low areas of the fields where soil remains wet for an extended period of time. *P. capsici* causes seedling damping-off, root and crown rot, leaf spots, vine lesions, foliar blight, and fruit rot. Crown rot causes the entire plant to collapse and die. Water-soaked lesions develop on vines. Lesions are dark olive initially and become dark brown within a few days. The lesions girdle the stem, resulting in rapid collapse and death of foliage above the lesion site. Fruit rot can occur from the time of fruit set until harvest, as well as after harvest, during transit or in storage. Fruit rot typically begins as a water-soaked lesion, which expands, and becomes covered with fluffy white mold. The pathogen produces numerous fruiting bodies (sporangia) on infected fruit. Fruit infection progresses rapidly, resulting in complete collapse of the fruit. Phytophthora blight may result in total loss of the crop.

Disease Cycle. *P. capsici* survives as thick-walled spores (oospores) in the soil for several years. Sporangia form when soil is moist and release motile spores (zoospores). Zoospores infect plants, and further disease development occurs rapidly because sporangia are produced abundantly on infected tissues and are easily dispersed.

Non-Chemical Control

- No cucurbit varieties with measurable resistance to Phytophthora blight are available.
- Select fields with no history of Phytophthora blight. An effective rotation period has not been identified.
- Well-drained fields should be selected and soil moisture should be kept as low as possible.
- Soil movement between fields should be avoided. Infected plants should be removed from the field and destroyed.

Chemical Control

- Seed treatment with mefenoxam prevents seedling infection.
- Foliar application of fungicides controls foliar and fruit infection.
- Registered active ingredients rated as “Good” in Appendix 3:
    - FRAC 4: mefenoxam (Apron XL LS, Ridomil, Ultra Flourish)
    - FRAC 15: dimethomorph (Acrobat)
    - FRAC 27, 11: cymoxanil + famoxadone (Tanos)
    - FRAC M5, 4: chlorothalonil + mefenoxam (Ridomil Gold Bravo)
- Registered active ingredients rated as “Good-Fair” or “Fair” in Appendix 3:
    - FRAC 27: cymoxanil (Curzate 60DF)
    - FRAC M1, M2: copper sulfate (Cuprofix Disperss)

    - FRAC M3: maneb (Maneb 75 DF, Manex)
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" in Appendix 3:
    - FRAC 21: cyazofamid

Action items

Research needs:

- Desire resistant varieties.
- What are the benefits from cover crops in reduce soil splashing?
- Investigate induced resistance.
- National testing of fungicides for uniformity (underway).
- Why is it showing up in fields that have not had cucurbits? Due to ponds, soil/air movement?
- Would soil tests help to predict disease incidence/severity? Dr. Babadoost is working on this now.
- Consider submitting USDA RAMP grant proposal (http://www.csrees.usda.gov/fo/fundview.cfm?fonum=1125)

Regulatory needs:

- Section 18 products are important.
- Ranman (cyazofamid) fungicide is expected soon.
- We need long-term solutions.

Education needs:

- Not using pond water as irrigation source.
- Avoid (plant around) known infected areas. Disk up active/infected areas before it spreads out.
- Host range for rotation planning.

Plectosporium Blight

Four-state rank: 1C (Common occurrence and easy to control)

Plectosporium blight (Microdochium blight), caused by the fungus *Plectosporium tabacinum (Microdochium tabacinum*), is an important disease of pumpkin and squash, and can cause yield losses of up to 100%.

Symptoms. The Plectosporium blight fungus infects stems, leaves, veins, petioles, and fruit. The disease is characterized by the production of light tan "bleached," sunken, spindle-shaped lesions on the stems, petioles, main leaf veins, and peduncles. Initially, the lesions are small, but they quickly coalesce, causing the entire surface of the stem or leaf vein to turn white. Because leaf lesions are restricted to the veins and do not spread to the interveinal tissue, they may be overlooked. Infected stems are dry and brittle. Leaves on the severely affected vines die and complete defoliation may occur. On fruit, the fungus causes white, tan, or silver russeting on the surface.

Disease Cycle. *P. tabacinum* occurs in soil and plant debris. The fungus produces two-celled, ellipsoidal to cylindrical and slightly curved spores. The spores are likely spread by rain-splash and wind, and initiate infection upon landing on host tissues. Warm, wet weather favors disease development.

Non-Chemical Control

- No resistant pumpkin or squash varieties to Plectosporium blight are known.
- Rotation with noncucurbit crops should help reduce disease incidence.

Chemical Control

- The disease is readily controlled by fungicide applications.
- Registered active ingredients rated as "Good" in Appendix 3:
    - FRAC 7, 11: boscalid + pyraclostrobin (Pristine)
    - FRAC 11: azoxystrobin (Amistar, Heritage, Quadris F), pyraclostrobin (Cabrio EG)
    - FRAC 11, M5: azoxystrobin + chlorothalonil (Quadris Opti)
- Registered active ingredients rated as "Good-Fair" or "Fair" in Appendix 3:
    - None
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" in Appendix 3:
    - None

Action items

Research needs:

- No comments.

Regulatory needs:

- Only pyraclostrobin is labeled. Need more options.
- Bravo seems to work well.

Education needs:

- No comments.

Powdery Mildew

Four-state rank: 1C (Common occurrence and easy to control)

Powdery mildew, caused by the fungi *Podosphaera xanthii* (syn. *Sphaerotheca fuliginea*) and *Erysiphe cichoracearum*, is one of the important diseases of cucurbits in the Midwest. It occurs in greenhouses and fields throughout most areas of the world. The vegetable crops most commonly affected are cucumber, gourd, muskmelon (cantaloupe), pumpkin, and squash.

Symptoms. Powdery mildew is diagnosed by white, powdery mold on plant tissues. Powdery fungal growth develops on both leaf surfaces, petioles, and stems. The

disease first appears on lower stems and petioles. As the disease continues to develop, the white, moldy spots occur on the underside of leaves, then on the upper leaf surfaces. Yellow spots may form on upper leaf surfaces opposite to powdery mildew colonies on the underside of leaves. Infected leaves usually weather and die.

Disease Cycle. The primary inoculum is believed to be airborne conidia dispersed over long distances, from greenhouse grown cucurbits, alternate hosts, and possibly cleistothecia. Cleistothecia, produced in the late growing season, are small, dark structures with thick walls that contain sexual spores. Powdery mildew develops quickly under favorable conditions (dense plant growth, low-intensity light, high relative humidity). The time between infection and symptom appearance is usually 3-7 days, and a large number of spores can be produced in this time. Infection can occur at 50–90°F (10–32°C). Plants in the field often do not become infected until after the initiation of fruit set.

Non-Chemical Control

- Varietal resistance to powdery mildew is usually partial and may require additional complementary control practices.
- Rotation with noncucurbit crops should help reduce disease incidence.

Chemical Control

- Fungicide application is a common control practice of powdery mildew. Plants should be inspected weekly, beginning at fruit set initiation, and sprayed with fungicides at the first sign of the disease. To accomplish effective control of powdery mildew, good fungicide coverage is needed on the undersides of leaves and inside the canopy. Spray volume of 50 gallons or more, applied with a pressurized sprayer, should provide a good coverage of the canopy.
- To minimize the potential of resistant development in the pathogens, systemic fungicides should be applied with contact fungicides and application of systemic fungicides with different modes of action should be alternated.
- Registered active ingredients rated as “Good” in Appendix 3:
    - FRAC 1: thiophanate-methyl (Topsin 70 WSB)
    - FRAC 3: myclobutanil (Nova 40W), triflumizole (Procure 50 WS)
    - FRAC 7, 11: boscalid + pyraclostrobin (Pristine)
    - FRAC 11: azoxystrobin (Amistar, Heritage, Quadris F), pyraclostrobin (Cabrio EG), trifloxystrobin (Flint)
    - FRAC 11, M5: azoxystrobin + chlorothalonil (Quadris Opti)
- Registered active ingredients rated as “Good-Fair” or “Fair” in Appendix 3:
    - FRAC not specified: potassium bicarbonate (Armicarb, Eco-Mate Armicarb "O")
- “Pipeline” active ingredients rated as “Good”, “Good-Fair” or “Fair” in Appendix 3:
    - FRAC 3: tebuconazole

Action items

Research needs:

- Baseline pathogen sensitivity (Nova, Procure, strobilurins)
    - Do we have different populations?
    - Northeastern researchers may have published on this?
- How do the resistance genes hold up to various populations?
- Are resistant varieties more attractive to cucumber beetles?

Regulatory needs:

- Bayleton was a great product. Was it removed from this market due to resistance?

Education needs:

- No comments.

Root-Knot Nematodes

Four-state rank: 3A (Uncommon occurrence and difficult ability to control)

Root-knot nematodes (*Meloidogyne* species) are destructive to cucurbit crops. Three species of root-knot nematodes, *M. incognita*, *M. hapla*, and *M. arenaria* are the most important root-knot species in cucurbits.

Symptoms. Root-knot nematode damage is usually associated with patches of stunted, chlorotic plants within a field. Infection of susceptible plant roots by root-knot nematodes results in the formation of galls or swellings on the roots. Above-ground symptoms of infected plants include yellowing of foliage, reduced size and number of leaves, excessive wilting in warm weather, and poor yield.

Life Cycle. Root-knot nematodes survive in roots of weeds or as eggs in infected roots of previous crops. The eggs hatch, go through four larval stages, and become adult nematodes. The duration of the life cycle is dependent on soil temperature and the host species; it is usually completed in 21-28 days at soil temperatures of 77-86°F (25-30°C).

Non-Chemical Control

- Laboratory analysis of soil samples is needed to accurately assess the number of nematodes present in the soil.
- Crop rotation is effective when nonhost crops (grasses) are included in the rotation. Root-knot nematodes have a wide host range (more than 2,000 plant species).
- Incorporating green manure or organic amendments, or maintaining fallow periods, will reduce nematode numbers in the soil.

Chemical Control

- Soil fumigants and nonfumigant nematicides are effective in reducing nematode numbers in the soil as well. Because fumigants are not used in pumpkin production due to high costs, the efficacy of these products was not considered.
- Registered active ingredients rated as "Good" in Appendix 3:
    - None
- Registered active ingredients rated as "Good-Fair" or "Fair" in Appendix 3:
    - IRAC 1A: oxamyl (Vydate L insecticide/nematicide)
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" in Appendix 3:
    - None

Action items

Research needs:

- No comments.

Regulatory needs:

- No comments.

Education needs:

- No comments.

Scab

Four-state rank: 3C (Uncommon occurrence and easy to control)

Scab of cucurbits is caused by the fungus *Cladosporium cucumerinum*. This disease is a problem for pumpkins when conditions are favorable for disease development.

Symptoms. All parts of foliage, stems, and fruit can become infected. On leaves and runners, pale green, water-soaked lesions are the initial symptoms. The lesions gradually turn gray to white and may become "shot-holed" in appearance. A chlorotic halo appears around the lesion. Scab causes the most damage on fruit. The appearance of fruit lesions varies in different crops, depending on the susceptibility of the crop. Lesions first appear as small, sunken areas (1/8- to 1/6-inch in diameter). A sticky substance may ooze from the infected areas. Secondary soft-rotting organisms may also invade the cavities and lead to a foul-smelling decay. On pumpkin fruit, lesions may appear as sunken craters and can lead to misshapen areas on the fruit.

Disease Cycle. The scab fungus survives on host debris in soil. The fungus also may be seed-borne. It is disseminated on clothing, equipment, and by insects. The spores can survive long-distance spread in moist air. The most favorable weather conditions for disease development are wet weather and temperatures near or below 70°F (21°C).

Non-Chemical Control

- The use of pathogen-free seed is important.
- Because the pathogen survives well overwinter, a crop-rotation schedule of two years between cucurbit crops and nonhost crops is necessary.
- Sites that have well-drained soils and good air movement (to allow for rapid drying of the foliage) are less favorable for disease development.

Chemical Control

- Fungicide application should be considered once the disease is detected.
- Registered active ingredients rated as "Good" in Appendix 3:
  - FRAC M5: chlorothalonil (Bravo, Echo, Equus)
- Registered active ingredients rated as "Good-Fair" or "Fair" in Appendix 3:
  - None
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" in Appendix 3:
  - None

Action items

Research needs:

- No comments.

Regulatory needs:

- No comments.

Education needs:

- No comments.

Sclerotinia Rot

Four-state rank: 3A (Uncommon occurrence and difficult ability to control)

Sclerotina rot, caused by the fungus *Sclerotinia sclerotiorum*, is relatively a minor problem for cucurbits. The disease is observed most often on pumpkin (particularly mini pumpkins) and squash.

Symptoms. Stems and fruit are affected. Infection tends to occur in dead tendrils or through withered flowers still attached to developing fruit. Cottony fungal growth (mycelium) develops on affected tissues. The fungus can cause fruit rot in the field or postharvest decay. Fruit are typically infected where they are in contact with soil. Hard, black structures (sclerotia) resembling small raisins are produced among the moldy growth.

Disease Cycle. The fungus can infect more than 300 different plant species. It survives in soil as sclerotia and as mycelium in plant debris. Sclerotia survive in soil for several years. A sclerotium either germinates and produces mycelium that infect a plant, or

produces a specialized structure (apothecium) that contains sexual spores (ascospores) that are dispersed by wind. Disease development is favored by cool and wet conditions.

Non-Chemical Control

- Crop rotation may not be an effective control method, because of the wide host range of the fungus.
- Deep plowing immediately after harvest can help to reduce disease incidence.
- Fields with good drainage should be considered.
- Overhead irrigation should be used during the day when leaves will dry before dew forms.

Chemical Control

- Fungicides may be effective if applied to young plants that could be threatened during cool, wet summers.
- Registered active ingredients rated as "Good" in Appendix 3:
  - None
- Registered active ingredients rated as "Good-Fair" or "Fair" in Appendix 3:
  - None
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" in Appendix 3:
  - None

Action items

Research needs:

- More of a problem in mini pumpkins compared to larger pumpkins.
- How well do Topsin and Nova work? When to spray?

Regulatory needs:

- Need some fungicide options.

Education needs:

- No comments.

Septoria Leaf Spot

Four-state rank: 2C (Intermediate occurrence and easy to control)

Septoria leaf spot, caused by the fungus *Septoria cucurbitacearum*, occurs on cucumber, melon, pumpkin, and squash, and may affect the marketability of these crops.

Symptoms. The pathogen causes similar symptoms on all cucurbit hosts. Symptoms first appear as small (1/25-inch), dark brown, water-soaked lesions on leaf tissues. The lesions gradually enlarge and may reach ¼-inch in diameter. Under dry conditions, they are circular or occasionally irregular in shape and beige to nearly white in color. A

narrow brown boarder surrounds the lesion and, with age, the tissue may crack. On older lesions, small black fruiting bodies (pycnidia) are formed, which are embedded in the tissue. Lesions are very abundant on melon, pumpkin, and winter squash leaves; they are less common on summer squash. Small, erumpent, whitish spots (1/25-inch) appear as a “rash” on the surface of infected butternut and acorn squash and pumpkin fruit.

Disease Cycle. The pathogen overwinters on crop debris and can survive for two years. The fungus most likely survives as dormant mycelium. In the spring, pycnidia develop, in which spores (conidia) are produced that serve as the primary inoculum. The needle-shaped conidia ooze out of pycnidia and are spread by splashing rain or wind. High humidity, rainfall, and temperatures between 61-66°F (16-19°C) are favorable conditions for infection and further disease development. If favorable weather conditions persist, the pathogen can produce additional inoculum and infection in repeated secondary cycles. Although disease development slows with warmer summer weather and lack of rainfall, reoccurrence of the disease in the fall is likely unless early controls are implemented.

Non-Chemical Control

- Septoria leaf spot can be managed by a 2-year crop rotation out of all cucurbits.

Chemical Control

- If cool and moist conditions persist in the early growing season, lesions will likely develop. Scouting at this time will allow for early detection and the scheduling of fungicide applications. Early control of the disease may preclude the need for additional applications in the fall.
- Registered active ingredients rated as “Good” in Appendix 3:
    - None
- Registered active ingredients rated as “Good-Fair” or “Fair” in Appendix 3:
    - None
- “Pipeline” active ingredients rated as “Good”, “Good-Fair” or “Fair” in Appendix 3:
    - None

Action items

Research needs:

- No comments.

Regulatory needs:

- No comments.

Education needs:

- Often confused with bacterial spot. Need to look for bumps and fruiting bodies.

Angular Leaf Spot

Four-state rank: 2A (Intermediate occurrence and difficult ability to control)

Angular leaf spot, caused by the bacterium *Pseudomonas syringae* pv. *lachrymans*, is a common disease of cucurbits.

Symptoms. Angular leaf spot first appears as small, water-soaked lesions on leaves. The lesions usually expand until they are delimited by larger secondary veins in the leaves, which give the lesions an angular appearance. Accompanying water-soaked appearance at high relative humidities is a clear to milky exudate, which collects in a tear (hence *lachrymans*, "tear" in Latin) on the lower surface of the lesion. The exudate dries to form a thin white crust on or adjacent to the lesion. On leaves, the lesions become dry, turn tan brown, and may drop out. Lesions also develop on petioles, stems, and fruits, on which the white crusty exudate can also be evident. On fruit, lesions appear as small, circular, water-soaked spots, and often with a light tan center. Infection frequently predisposes fruit to bacterial soft rot.

Disease Cycle. The pathogen is seed-borne, with the infestation occurring within the seed coat, so that upon germination, the cotyledons are infected. It is spread from plant to plant by splashing rain, insects, on the hands and arms of pickers, and on farm machinery. Spread is enhanced when the foliage is wet. The bacterium enters stomates, hydathodes (specialized leaf structures through which water is discharged from the leaf), and wounds. Windblown sandy soil containing infested debris is particularly effective in spreading the disease, as is irrigation water contaminated with the bacterium. Bacteria multiplying in the placental tissues may reach the developing seed and infect the seed coat. The bacteria overwinter in infested crop residues and can live for up to two and a half years in dry leaves.

Non-Chemical Control

- No pumpkin cultivars are known to be resistant to this disease.
- Primary control is the use of pathogen-free seed. Treatment of cucurbit seed for 20 minutes with water at 122°F (50°C) containing tartaric acid or acidic cupric acetate, reduces but does not entirely eliminate the bacteria from seed.
- Crop rotation with non-cucurbit crops should be practiced for at least two years.
- Cultivation of soil when it is dry reduces bacterial survival.
- Where possible, overhead irrigation should be avoided. Surface drainage water near cucurbit fields should not be used for irrigation. Entering fields for work or harvesting should be avoided when the foliage is wet.

Chemical Control

- Application of copper sprays as a foliar protectant may reduce spread of angular leaf spot. Spraying with copper, however, is generally ineffective once an epidemic is underway.
- Registered active ingredients rated as "Good" in Appendix 3:
    - None
- Registered active ingredients rated as "Good-Fair" or "Fair" in Appendix 3:

    - FRAC M1: copper (Tenn-Cop, Champ, Kocide, KOP)
    - FRAC M1, M2: copper sulfate (Cuprofix Disperss)
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" in Appendix 3:
    - None

Action items

Research needs:

- No comments.

Regulatory needs:

- No comments.

Education needs:

- No comments.

Bacterial Leaf & Fruit Spot

Four-state rank: 1A (Common occurrence and difficult to control)

Bacterial spot, caused by the bacterium *Xanthomonas campestris* pv. *cucurbitae*, is a serious disease of cucurbits. This disease has been reported on cucumbers, gourds, pumpkins, and summer and winter squashes. Outbreaks of bacterial spot in Illinois, however, have been observed only on pumpkin. Yield losses caused by this disease exceed 50% in fields under moist conditions.

Symptoms. Symptoms on leaves appear as small, dark lesions, with indefinite yellow margins. The lesions may coalesce to form larger necrotic areas, usually on leaf margins. The most readily identifiable symptoms occur on fruit. The appearance and size of fruit lesions can vary, depending on rind maturity and the presence of moisture. Initial lesions are small, slightly sunken, circular spots, 1/16- to ¼-inch in diameter, with beige centers and dark- brown halos. Later, the cuticle and epidermis crack, with the lesions enlarging and reaching ½-inch in diameter. The large lesions may have a scab-like appearance and give rise to tan, raised blisters. On mature fruit, saprophytic fungi often colonize the dead, tan tissue at the center of the lesion. Penetration of bacteria into the flesh can lead to significant fruit rot in the field or later in storage.

Disease Cycle. The bacterium is a seed-borne pathogen. Also, the bacteria can survive in association with infested crop residue. The disease appears during the summer months when temperatures are high, and most commonly after heavy rain, dew, or overhead irrigation. Fruit infection occurs through natural openings in young, rapidly expanding fruit prior to the development of a thick, waxy cuticle. The bacteria are splash-spread in the field. Spread of the bacteria within fields can be very rapid. Long distance dispersal of the pathogen is by contaminated seed.

Non-Chemical Control

- The most effective method for control of the disease is planting pathogen-free seed.
- Rotation with noncucurbit crops is effective in management of the disease.

Chemical Control

- Application of copper compounds during early formation and expansion of fruit may result in substantially fewer symptomatic pumpkins. Copper sprays, however, are ineffective once an epidemic is underway.
- Registered active ingredients rated as "Good" in Appendix 3:
  - None
- Registered active ingredients rated as "Good-Fair" or "Fair" in Appendix 3:
  - FRAC M1: copper (Tenn-Cop, Champ, Kocide, KOP)
  - FRAC M1, M2: copper sulfate (Cuprofix Disperss)
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" in Appendix 3:
  - None

Action items

Research needs:

- Really lacking biological information worldwide.
- Are there differences in susceptibility among varieties?
- Seed/soil sanitation & rotation: How important are they in preventing spread?
  - How much background inoculum (in soil) is there?
- Is this pathovar really seed-borne? Need to prove or disprove for pumpkin and provide a basis for seed companies to react.
- A company in Colorado can test for seed-borne inoculum.
  - What is their limit of detection? Is it low enough?

Regulatory needs:

- What level of seed contamination is "contaminated"? Need a definition; lots of legal issues between seed companies and producers.

Education needs:

- No comments.

Bacterial Wilt

Four-state rank: 3B (Uncommon occurrence and intermediate ability to control)

Bacterial wilt, caused by the bacterium *Erwinia tracheiphila*, is considered a serious disease of cantaloupe and cucumber, but it is less damaging on pumpkin.

Symptoms. The expression of bacterial wilt symptoms varies with different crop species. Cucumber and melon are severely affected by the disease. Individual runners

or whole plants wilt and die rapidly. Affected runners appear dark green at first and then become necrotic as the wilt advances. Symptoms appear at all stages of plant development, but wilting is most severe early in the season, when plants are growing rapidly. Pumpkin and squash also develop bacterial wilt. Plants may wilt dramatically during the heat of the day, but partially recover by morning. Interveinal areas of leaves become yellowish, even whitish, and eventually die, but the main veins remain green. Necrosis eventually develops on the leaf margins before the entire plant collapses and dies. A common diagnostic test for bacterial wilt involves cutting a wilted runner close to the crown of the plant, rejoining the cut surfaces for a moment, and then slowly drawing apart the cut ends. The presence of bacterial slime (masses of bacteria streaming from xylem tissues) extending from one cut surface to the other is a positive indication for bacterial wilt.

Disease Cycle. The bacteria are transmitted by the striped cucumber beetle (*Acalymma vittatum*) and the spotted cucumber beetle (*Diabrotica undecimpunctata howardi*). The western spotted cucumber beetle (*Diabrotica undecimpunctata undecimpunctata*) and the banded cucumber beetle (*Diabrotica balteata*) also may transmit the bacteria. The pathogen is transmitted into the plant through contact with contaminated beetle mouth parts. The adult beetles feed on cotyledons, leaves, stems, and fruit. The bacteria multiply at the wound site, enter the xylem vessels, then move down the petiole and stem. Vascular plugging by masses of bacteria and subsequent formation of gums and resins are the primary mechanisms of wilting. The striped cucumber beetle, *A. vittatum*, is considered the overwinter reservoir for the pathogen. The bacteria remain viable in dried plant debris for only a very short period of time. Death of the pathogen accompanies the deterioration of plant stems. The bacteria are not seed-transmitted.

Non-Chemical Control

- None.

Chemical Control

- Control of bacterial wilt depends on the control of cucumber beetles. Applications of contact or systemic insecticides are needed for beetled control, thus control of bacterial wilt disease. For control measures, see “Cucumber Beetles” within the Insect and Insect Relatives chapter.

Action items

Research needs:

- Susceptibility of different varieties.
- Do cucumber beetles prefer certain varieties?

Regulatory needs:

- No comments.

Education needs:

- Only a problem up to about the 5-leaf stage.

Yellow Vine Disease

Four-state rank: 2B (Intermediate occurrence and intermediate ability to control)

Cucurbit yellow vine is a newly described disease of cantaloupe, pumpkin, squash, and watermelon.

Symptoms. Symptoms of yellow vine generally appear during fruit set. Leaves near the crown of the plant or entire plants turn pale green and then bright yellow. Yellowing and leaf death generally progress outward from the crown. Eventually, entire plants are killed. The key diagnostic feature for yellow vine is a light brown discoloration of the phloem, visible in cross section in the lower stem and roots. The distribution of the disease in the field is patchy, and edges of the field are often severely affected.

Causal Organisms. Cucurbit yellow vine disease is caused by *Serration marcencens*. *S. marcescens* is a gram negative bacterium producing creamy white, smooth, convex colonies on nutrient agar. The squash bug (*Anasa tristis*) has been identified as a vector of the yellow vine bacterium.

Non-Chemical Control

- None.

Chemical Control

- At present, there are no satisfactory measures available for control of yellow vine of cucurbits. Controlling squash bug is beneficial. For control measures, see "Squash Bug" within the Insect and Insect Relatives chapter.

Action items

Research needs:

- In this region, we have never see it on watermelon or cantaloupe. Do we have a different (another) vector here?
- What is the biology/etiology of yellow vine disease? Koch's Postulates (to confirm pathogenicity) has not yet been performed in some states.

Regulatory needs:

- No comments.

Education needs:

- Misdiagnosis: Is this disease occurring more often than we think?
- Many diagnostic labs are not equipped to do PCR testing for the bacterium that causes yellow vine disease.

Viral Diseases

Four-state rank: 1A (Common occurrence and difficult to control)

Most common viral diseases in the Midwest are caused by cucumber mosaic virus, papaya ringspot virus-type W, squash mosaic virus, watermelon mosaic virus, and zucchini yellow mosaic virus.

Cucumber Mosaic Virus (CMV). CMV causes foliar mosaics and mottled fruit. CMV can infect about 800 plant species, including many vegetable crops, ornamentals, and woody plants. Many weeds and cultivated crops are reservoirs of this virus. CMV is transmitted by more than 60 aphid species. Eradication of weed hosts is often impossible.

Papaya Ringspot Virus - Type W (PRSV-W). PRSV-W causes plant stunting, mosaic and fern-leaf appearance on foliage, and color breaking and malformation on fruit. The natural host range of PRSV-W is confined to the Cucurbitaceae. PRSV-W is transmitted by more than 20 aphid species.

Squash Mosaic Virus (SqMV). SqMV causes veinbanding, mosaic, mottling, and blister on foliage. Plants are often stunted, producing malformed and mottled fruit. SqMV is a seed-borne pathogen. This virus is transmitted by the striped and spotted cucumber beetles.

Watermelon Mosaic Virus (WMV). WMV infects most of the cucurbits and many leguminous species. WMV causes green mosaic, leaf rugosity, green veinbanding, chlorotic rings, and malformation on foliage, and green ringspots and mottling of fruit. WMV is spread by more than 20 aphid species.

Zucchini Yellow Mosaic Virus (ZYMV). ZYMV causes yellow mosaic, a deep fernlike appearance of the foliage, and bumpy and mottled fruit. ZYMV is spread by several aphid species.

Non-Chemical Control

- Planting resistant or tolerant cultivars (if available) can control CMV, PRSV-W, WMV, and ZYMV.
- Use of virus-free seed is an important control measure for SqMV.

Chemical Control

- Fungicides and bactericides can not protect against viruses.
- Insecticides can not prevent the spread of CMV, PRSV-W, WMV, or ZYMV.
- Spread of the SqMV can be reduced by controlling beetle vectors through the use of insecticides. For control measures, see “Cucumber Beetles” within the Insect and Insect Relatives chapter.

Action items

Research needs:

- See action items under “Aphids”, “Cucumber Beetles” and “Whiteflies” within the Insect and Insect Relative chapter.
- Reflective plastic mulch is not practical for wholesale, direct-seeded operations. It is also costly. Does it have a niche (e.g., bush-type, organic, transplant)?
- Are there plants that repel vectors?
- Genetic resistance
    - GMO resistance options? (Processor concerns about GMOs)
    - Apparently there are *C. pepo* varieties in the pipeline with resistance (via Seminis).

Regulatory needs:

- See action items under “Aphids”, “Cucumber Beetles” and “Whiteflies” within the Insect and Insect Relative chapter.

Education needs:

- See action items under “Aphids”, “Cucumber Beetles” and “Whiteflies” within the Insect and Insect Relative chapter.

INSECTS & INSECT RELATIVES

Aphids

Four-state rank: 1C (Common occurrence and easy to control)

Many aphid species "pass through" plantings of cucumbers, squash, pumpkins, and melons, but few settle, survive, and colonize cucurbits. The most common colonizers are cotton-melon aphid, *Aphis gossypii* (Glover) and the green peach aphid, *Myzus persicae* (Sulzer) (Homoptera: Aphididae). The soybean aphid, *Aphis glycines* (Matsumura) is among the many species that blow across cucurbit plantings and may land and feed briefly before moving on.

Identification. Aphids are small, pear-shaped insects less than 1/10 inch in length. Adults may be winged or wingless, and all three of the species named above bear a pair of tailpipe-like projections called cornicles. Wingless forms of these three aphids are pale green to yellowish in color, and winged adults are darker-bodied, with transparent wings. Identification of most aphids to the species level is not practical for growers or crop consultants.

Life Cycle. Most of the aphid species that colonize or pass through cucurbit plantings do not overwinter in the Midwest. Instead they migrate into the region each spring or summer on weather fronts from the south. Through most or all of the season, females are parthenogenic – they reproduce without mating – and they give birth to live young instead of laying eggs. Where cotton-melon aphid establishes on cucurbits, each female may produce 50-100 offspring, and each nymph matures to the adult stage in 5 days under optimal conditions.

The soybean aphid, though not a direct pest of cucurbits, may be important as a vector of such viruses as cucumber mosaic virus, watermelon mosaic virus, and zucchini yellow mosaic virus. This insect does overwinter in Illinois, and it does so as eggs on buckthorn, a woody shrub. Eggs hatch in the spring, and a few generations of aphids develop on buckthorn (*Rhamnus* spp.) before they migrate to their summer host, soybeans (*Glycines* max). In late summer, subsequent generations migrate back to buckthorn. During these migrations, soybean aphids land and make feeding probes on a wide variety of plants, including weeds that may harbor the mosaic viruses mentioned above, as well as cucurbits. When they feed on a virus-infected weed and then feed on a cucurbit, they transmit the virus to the crop plant. Large numbers of soybean aphids may pose an increasing threat for virus infections in cucurbits and other vegetable crops in the Midwest.

Plant Injury. Aphids that colonize cucurbits may injure plants directly by removing plant sap, reducing vigor and yield. Plants with a heavy infestation of aphids may be stunted and the leaves may have necrotic spots and a mottled, cupped appearance. Viruses carried by aphids can be a much more severe problem; if infections occur early in plant development, the crop may not produce any marketable fruit.

Non-Chemical Control

Steps that reduce the movement of viruses into cucurbit plantings or reduce overall losses to virus diseases transmitted by aphids include:

- Planting early (before migrant aphids arrive from the south).
- Staggering plantings over several dates.
- Separating plantings over available space.
- Planting cucurbits in the centers of weed-free border crops that are not hosts to the mosaic viruses (corn and small grains are such crops).
- Planting into reflective mulches that reduce the numbers of aphids landing in the crop during its early stages of growth.

Chemical Control

- Applying insecticides to aphid-infested cucurbits can be an effective way to control colonies of species such as cotton-melon aphid and green peach aphid. However, insecticides are <u>not</u> effective for preventing virus infections, because virus transmission occurs in what is called a nonpersistent manner. Thus, aphids pick up the virus from an infected plant (usually a weed) and transmit the virus to the very next plant on which they feed. They lose most of their virus load in one or two feeding probes, and by the time they are killed by an insecticide, they are already noninfectious (so killing them did nothing to prevent or reduce the introduction of the virus into the field).
- Registered active ingredients rated as “Good” in Appendix 4:
    - Insecticide Resistance Action Committee (IRAC) Group 1B: malathion (Malathion 57 EC) and oxydemeton-methyl (MSR Spray Concentrate)
    - IRAC 3: bifenthrin (Capture 2 EC) and permethrin (Ambush 25W, Pounce)
    - IRAC 4A: imadacloprid (Admire 2F) and thiamethoxam (Platinum)
    - IRAC 9B: pymetrozine (Fulfill)
    - IRAC unclassified: potassium salts (M-Pede)
- Registered active ingredients rated as “Good-Fair” or “Fair” in Appendix 4:
    - IRAC 1A: oxamyl (Vydate L)
    - IRAC 2A: endosulfan (Endosulfan, Phaser 3EC, Thiodan)
    - IRAC 3: fenpropathrin (Danitol 2.4 EC)
- “Pipeline” active ingredients rated as “Good”, “Good-Fair” or “Fair” in Appendix 4:
    - IRAC 4A: thiacloprid

Action items

<u>Research needs:</u>

- Very localized virus infections – why?
- Where is the virus reservoir?
    - Can soybean support any cucurbit viruses? Virus outbreaks in pumpkin seem to be correlated with high soybean aphid populations.
- Study of cultural practices which may reduce the problem.
    - Earlier planting date may help, but this date is dictated by marketing times.
- Can we stop/reduce secondary virus spread?
- Do we need to know which aphids are in the field?

    - Dr. Voegtlin (Illinois) indicates that aphids which deliver the virus to the field may not be the same as the species that spread the virus within the field.
- Virus-resistance – is anyone researching this?
    - Dr. Babadoost (Illinois) says at least one company is.
    - Processors would not accept GMO forms (not a yield limiting factor anyway).

Regulatory needs:

- No comments.

Education needs:

- Dr. Welty (Ohio) studied viruses in perennial weed hosts.

Corn Rootworm Beetles

Four-state rank: 1C (Common occurrence and easy to control)

In addition to the spotted and striped cucumber beetles, adults of two closely related species, the western corn rootworm, *Diabrotica virgifera virgifera* (LeConte), and the northern corn rootworm, *Diabrotica barberi* (Smith & Lawrence) (Coleoptera: Chrysomelidae) may feed on pumpkins in late summer and early fall.

Identification. The western corn rootworm adult is a beetle that is about ¼-inch long and resembles the striped cucumber beetle. The stripes on its forewings are not as distinct and complete as those on the striped cucumber beetle, and the underside of its abdomen is yellowish (not black as it is on the striped cucumber beetle). The northern corn rootworm is similar in size and shape, but its body color is a uniform, pale yellowish green. Larvae are whitish, ½- to ¾-inch long, with dark brown heads and 3 pairs of short legs on the thorax; they feed exclusively on the roots of corn.

Life Cycle. These two corn rootworm species overwinter only as eggs. "Typical" (wild-type) adult females lay eggs only in the soil of corn fields, but populations in eastern and central Illinois (and further to the east and northeast) include a strain that lays eggs in soybean, small grains and alfalfa. The egg stage overwinters in the soil, and larvae hatch in early summer to feed on the roots of corn. Adults emerge in midsummer and feed on pollen and silks of corn as well as the flower parts of a variety of plants, including cucurbits, during late summer. Only one generation develops each year.

Plant Injury. Corn rootworm beetles do not cause significant injury to the foliage of cucurbits and they are not significant vectors of bacterial wilt. In general (in most years), they are pests only as a result of their feeding on the fruits of pumpkins and other late-season cucurbits, causing cosmetic injury and opening the fruit to pathogens that cause fruit rot.

Non-Chemical Control

- None.

Chemical Control

- Control of western and northern corn rootworm beetles in cucurbits generally is necessary only in pumpkin in areas where adults are particularly numerous.
- Registered active ingredients rated as "Good" in Appendix 4:
    - IRAC 1A: carbaryl (Sevin 80 WSP, 80S, XLR+)
    - IRAC 3: bifenthrin (Capture 2 EC), esfenvalerate (Asana XL), fenpropathrin (Danitol 2.4 EC), permethrin (Ambush 25W, Pounce)
    - IRAC 4A: imadacloprid (Admire 2F)
- Registered active ingredients rated as "Good-Fair" or "Fair" in Appendix 4:
    - IRAC 1B: malathion (Malathion 57 EC)
    - IRAC 4A: thiamethoxam (Platinum)
    - IRAC 5: spinosad (Entrust, SpinTor, Success)
    - IRAC 21: rotenone
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" in Appendix 4:
    - IRAC: cyfluthrin, zeta-cypermethrin

Action items

Research needs:

- No comments.

Regulatory needs:

- No comments.

Education needs:

- No comments.

Cucumber Beetles

Four-state rank: 1C (Common occurrence and easy to control)

Spotted cucumber beetle, *Diabrotica undecimpuntata howardi* (Barber), and striped cucumber beetle, *Acalymma vittata* (Fabricius) (Coleoptera: Chrysomelidae) are common pests of all cucurbits throughout the Midwest.

Identification. Spotted cucumber beetles are about ¼-inch long, with yellow-green forewings ("wing covers") marked with 12 black spots. Striped cucumber beetles are similar in size with two black stripes that run the length of each forewing (the inner stripes of the left and right wings are adjacent when the beetles are at rest, so they appear to have 3 stripes, not 4). Western corn rootworms resemble striped cucumber beetles, but the underside of the abdomen of the striped cucumber beetle is black, whereas the abdomen of the western corn rootworm is yellow. Larvae are whitish, ½- to ¾-inch long, with dark brown heads and 3 pairs of short legs on the thorax.

Life Cycle. Adults of both species overwinter in wooded areas, primarily in plant debris, and become active as temperatures rise in spring, as early as April or May in southern Illinois. Overwintering mortality of spotted cucumber beetles may be high in much of the region. Consequently, populations in the northern Midwest depend, at least in part, on annual migration from the south. Adults feed on pollen and flower petals of many plant species until cucurbits are planted, then they feed on the foliage and later the fruit of pumpkins, squash, cucumbers, and melons. Adults lay eggs in the soil, typically at the base of cucurbits and other plants (including corn for the spotted cucumber beetle, also known as the southern corn rootworm), and larvae feed for 2 to 3 weeks on the roots. In southern Illinois, two generations of larvae may develop each season, producing midsummer and late summer broods of adults; only one generation develops in northern Illinois in most seasons.

Plant Injury. Adult cucumber beetles injure cucurbits by chewing holes in foliage and feeding directly on fruits. They spread squash mosaic virus within plantings, and they also transmit the bacterial pathogen that causes bacterial wilt of cucurbits, a serious disease in muskmelons, cantaloupe, cucumbers, processing pumpkins, and Hubbard and butternut squash. Bacterial wilt rarely affects jack-o-lantern type pumpkins.

Non-Chemical Control

- Crop rotation.

Chemical Control

- Soil-applied systemic insecticides can be used at planting to kill beetles that feed on foliage of new seedlings.
- Begin scouting for adult beetles as soon as seedlings emerge or transplants are set. If transmission of bacterial wilt is a concern, use foliar applications of insecticides to control cucumber beetles if populations exceed 1 per 10 plants at the seedling stage or 1 per plant after flowering. On jack-o-lantern pumpkins, use foliar insecticides if populations exceed 5 per plant or if beetles (including the related western corn rootworm beetle) are feeding directly on fruits and causing excessive cosmetic damage.
- Insecticides can reduce spread of squash mosaic virus but NOT the aphid-transmitted mosaic viruses.
- Registered active ingredients rated as “Good” in Appendix 4:
    - IRAC 1A: carbaryl (Sevin 80 WSP, 80S, XLR+), carbofuran (Furadan 4F)
    - IRAC 3: bifenthrin (Capture 2 EC), esfenvalerate (Asana XL), fenpropathrin (Danitol 2.4 EC), permethrin (Ambush 25W, Pounce)
    - IRAC 4A: imadacloprid (Admire 2F)
- Registered active ingredients rated as “Good-Fair” or “Fair” in Appendix 4:
    - IRAC 1B: malathion (Malathion 57 EC)
    - IRAC 2A: endosulfan (Endosulfan, Phaser 3EC, Thiodan)
    - IRAC 4A: thiamethoxam (Platinum)
    - IRAC 5: spinosad (Entrust, SpinTor, Success)
    - IRAC 21: rotenone
- “Pipeline” active ingredients rated as “Good”, “Good-Fair” or “Fair” in Appendix 4:

- IRAC: cyfluthrin, zeta-cypermethrin

Action items

Research needs:

- No comments.

Regulatory needs:

- No comments.

Education needs:

- No comments.

Grasshopper

Four-state rank: 3B (Uncommon occurrence and intermediate ability to control)

Grasshoppers are familiar insects that feed on a wide variety of plants. Although their damage is usually insignificant, grasshoppers can be devastating pests when conditions are right.

Identification

There is a wide variety of grasshoppers present in the Midwest. Although they vary in appearance and size, grasshoppers all have the familiar enlarged hind legs that allow them to jump long distances. Adults have leathery wings and can fly.

Life Cycle

Most grasshopper species overwinter as eggs. Nymphs hatch in spring and feed gregariously during most of the immature stage. The entire life cycle generally takes 35-60 days to complete.

Plant Injury

Grasshoppers are defoliators, capable of removing large amounts of leaf tissue and leaving the leaves with a ragged appearance. When populations are high, complete defoliation can occur.

Non-chemical Control

- Fall or spring tillage can destroy many of the grasshopper eggs in the field.
- Most grasshoppers will come from weedy areas around the field. Controlling weeds in non-crop areas may reduce grasshopper populations for some species that do not migrate long distances. However, destruction of the weeds may cause other grasshopper species to move into the crops.
- Grasshoppers have a number of natural enemies. Birds are important predators, along with a number of insects. There are also several parasites that affect the egg, immature and adult stages. Nematodes can also be a significant mortality factor. However, when conditions are unfavorable for natural enemies, they will not suppress grasshopper populations sufficiently to avoid economic problems.

Chemical Control

- The best chemical control of grasshoppers is most likely to be obtained with pyrethroid insecticides such as Asana and Capture or with Sevin or Sevin baits.
- Registered active ingredients rated as "Good" in Appendix 4:
  - IRAC 1A: carbaryl (Sevin 80 WSP, 80S, XLR+)
  - IRAC 3: bifenthrin (Capture 2 EC), esfenvalerate (Asana XL), fenpropathrin (Danitol 2.4 EC), permethrin (Ambush 25W, Pounce)
- Registered active ingredients rated as "Good-Fair" or "Fair" in Appendix 4:
  - IRAC 1B: malathion (Malathion 57 EC)
  - IRAC 2A: endosulfan (Endosulfan, Phaser 3EC, Thiodan)
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" in Appendix 4:
  - None.

Action items

Research needs:

- No comments.

Regulatory needs:

- No comments.

Education needs:

- No comments.

Pickleworm

Four-state rank: 3B (Uncommon occurrence and intermediate ability to control)

Pickleworms feed on most cucurbits and can cause significant damage to summer squash and pumpkins, their preferred hosts.

Identification

Pickleworm adults have a 2.5 cm wing span with wings that are white near the base and iridescent with a band of dark brown around their perimeter. Pickleworm adults are not found in the field during the day. Eggs are laid in clusters of 2 to 6. Initially white, the eggs turn yellow 2 to 4 hours after being laid. The first four instars are white with black spots. At the fifth instar, pickleworm larvae lose their spots.

Life Cycle

Pickleworms overwinter south of Orlando, Florida, where they can be season-long pests. They must migrate each year to the Midwest, sometimes reaching as far north as Michigan. This migration must be assisted by strong southerly winds, and the moths usually do not arrive until August or September.

Pickleworms complete their life cycle in about 30 days, so in the Midwest only 1 or possibly 2 generations are important. Eggs are laid in clusters of 2 to 7, hatching in

about 4 days. There are five larval instars, lasting about 2 weeks. Pupation usually occurs in a leaf fold. Pickleworm moths fly mostly between dusk and early morning and are not usually seen in fields during the day.

Plant Injury

Pickleworms may feed on foliage, to the extent that only veins are left, giving the plant a lace-like appearance. The blossom, however, is the favored feeding site. Pickleworms feed on multiple blossoms, reducing the plant's capacity to produce fruit. Typically, pickleworms bore into and tunnel through fruit. Their entrance hole is small and difficult to find and is often plugged with frass. Once entry has occurred, fungal or bacterial diseases often develop in the fruit.

Non-chemical Control

- Because of their migratory nature, most cultural control methods, such as crop rotation or crop refuse destruction are not effective.
- Pickleworms have several natural enemies, none of which will provide acceptable levels of control.

Chemical Control

- Because pickleworms are not a consistent problem in the Midwest, insecticide applications should only be made when the presence of pickleworms is confirmed by scouting. Beginning in early July, growers should scout for pickleworms by inspecting 50 growing points and 50 blossoms for young larvae. Fifty fruit also should be examined for larval feeding, especially the underside of the fruit. Insecticides should be applied if any pickleworm larvae or damage is found.
- *Bacillus thuringiensis* insecticides can be used when larvae are small.
- Pyrethroid insecticides (Capture, Asana) and SpinTor have provided good to fair control.
- Registered active ingredients rated as “Good” in Appendix 4:
    - IRAC 3: bifenthrin (Capture 2 EC), esfenvalerate (Asana XL), fenpropathrin (Danitol 2.4 EC), permethrin (Ambush 25W, Pounce)
- Registered active ingredients rated as “Good-Fair” or “Fair” in Appendix 4:
    - IRAC 1A: carbaryl (Sevin 80 WSP, 80S, XLR+)
    - IRAC 1B: malathion (Malathion 57 EC)
    - IRAC 2A: endosulfan (Endosulfan, Phaser 3EC, Thiodan)
    - IRAC 5: spinosad (Entrust, SpinTor, Success)
    - IRAC 18: methoxyfenozide (Intrepid 2F)
- “Pipeline” active ingredients rated as “Good”, “Good-Fair” or “Fair” in Appendix 4:
    - None.

Action items

<u>Research needs:</u>

- No comments.

Regulatory needs:

- No comments.

Education needs:

- No comments.

Seedcorn Maggot

Four-state rank: 2B (Intermediate occurrence and intermediate ability to control)

The seedcorn maggot, *Delia platura* (Meigen) (Diptera: Anthomyiidae), and related species in the genus *Delia* are common early-season pests of several large-seeded crops, including the cucurbits, corn, beans, soybeans, and peas.

Identification. Adult seedcorn maggot flies are a bit less than ¼-inch long and grayish-black with black legs and numerous hairs. Larvae are legless maggots that reach about ¼ inch in length at maturity. The body covering of the final larval stage becomes a hardened, reddish-brown case (called a puparium) in which the insect pupates; the puparium is also about ¼-inch long.

Life Cycle. Seedcorn maggots overwinter as pupae in the soil, and emergence of adults often occurs as early plantings of corn, soybeans, and early vegetable crops are underway. Adult females prefer to deposit their eggs in soils where seeds have been planted and especially where organic amendments (green manure or animal manure) have recently been added. Larvae hatch in 7 to 10 days and feed on decaying organic matter, germinating seeds, or the stems of new seedlings, reaching pupation in 1 to 3 weeks, depending on soil temperatures. Through the spring and summer, adults emerge from pupae within 1 to 3 weeks. Three to 6 generations develop each year. Individuals that reach pupation in the fall remain in the pupal stage within puparia through the winter.

Plant Injury. Larvae feed on germinating seeds and on below-ground portions of seedlings, killing them or allowing the entry of soil-borne pathogens that cause damping off (death of seedlings due to fungal infections). Injury and stand loss is greatest during cool, wet weather and in soils where green manures or animal manures have been incorporated shortly before planting.

Non-Chemical Control

- Losses to seedcorn maggot can be reduced by:
    - using transplants.
    - waiting to seed into warm soils.
    - not seeding into fields where green manure or animal manure has not yet decomposed well (or at least waiting for soils to warm and allow rapid germination).

- Where seedcorn maggot infestations cause stand losses in early plantings, those areas can be replanted (reseeded) immediately without risk of repeated attack because the early flight of egg-laying adults will have ended.

Chemical Control

- Seed treatment insecticides (e.g., Lorsban) and systemic insecticides applied to soil (e.g., Furadan or Admire) around the seed for control of cucumber beetles also will control seedcorn maggot.
- Registered active ingredients rated as "Good" in Appendix 4:
    - IRAC 1B: chlorpyriphos (Lorsban 30, 50-SL)
    - IRAC 4A: imidacloprid (Admire 2F), thiamethoxam (Platinum)
- Registered active ingredients rated as "Good-Fair" or "Fair" in Appendix 4:
    - IRAC 1A: carbofuran (Furadan 4F)
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" in Appendix 4:
    - None

Action items

Research needs:

- Is this insect correlated with large populations of winter annuals in no-till?

Regulatory needs:

- We really need seed treatments (e.g., clothianidin, imidacloprid, thiacloprid and thiamethoxam). In contrast to chlopyriphos, these active ingredients are systemic and would provide protection of seeds and seedlings as well as larger plants.

Education needs:

- If this insect is correlated with large populations of winter annuals in no-till, promote the use of fall-applied Roundup to control winter annuals.
- More of a problem with early planting and with processing pumpkins.
- Use forecasting models based on soil temperature and oviposition; useful for timing the planting.

Squash Bug

Four-state rank: 1C (Common occurrence and easy to control)

The squash bug, *Anasa tristis* (De Geer) (Hemiptera: Coreidae), is a perennial and severe pest of pumpkins and squash; It rarely injures cucumbers and melons in the Midwestern United States.

Identification. The squash bug is a "true bug" in the order Hemiptera. Like all adult Hemipterans, adult squash bugs have two pairs of wings, with the front wings hardened at the base and membranous at the tips. Its mouthparts form a needle-like beak that arises from the tip of the head. Adults are brownish black, with yellowish to red-orange

markings; they appear oval shaped when viewed from above, and somewhat flattened when viewed from the side. Females lay yellowish-white eggs in small clusters or masses on the upper and lower surfaces of leaves; the eggs quickly darken to a reddish brown color. Eggs hatch to produce grayish-white, wingless nymphs with black legs. The nymphs darken in color as they grow older, and wing pads (the beginnings of wings) begin to develop.

Life Cycle. The squash bug overwinters as an adult, and survival is greatest in plant debris, mulch, and field borders or woods. Adults become active in the spring, mate, and females begin feeding and laying eggs in June and July. After hatching out from the eggs, nymphs mature to the adult stage in 5 to 6 weeks, and new females mate and begin laying eggs immediately. Populations are greatest during hot, dry summers. Females that reach the adult stage after late July or early August do not mate or lay eggs, but instead enter an inactive stage and seek overwintering sites. Squash bugs may be present as nymphs or adults in pumpkins and squash from June through October.

Plant Injury. Squash bugs use piercing mouthparts to penetrate stems, leaves, and fruit and suck sap from the plants. This direct damage may cause wilting or even kill plants if populations are large enough. Recent research has found that squash bugs transmit squash yellow vine disease; controlling squash bugs limits the spread of this disease within fields.

Non-Chemical Control

- Crop residue destruction
- Crop rotation

Chemical Control

- Early in the season, when adults move into fields and feed on young plants, watch for wilting of seedlings and apply an insecticide if adults are present and wilting is observed. Scout for eggs of the squash bug on the upper and lower surfaces of leaves. If densities exceed one egg mass per plant, use insecticides for control as nymphs begin to hatch. Insecticides labeled for use against squash bug are most effective against young nymphs.
- Registered active ingredients rated as “Good” in Appendix 4:
    - IRAC 3: bifenthrin (Capture 2 EC)
- Registered active ingredients rated as “Good-Fair” or “Fair” in Appendix 4:
    - IRAC 2A: endosulfan (Endosulfan, Phaser 3EC, Thiodan)
    - IRAC 3: esfenvalerate (Asana XL), fenpropathrin (Danitol 2.4 EC), permethrin (Ambush 25W, Pounce)
- “Pipeline” active ingredients rated as “Good”, “Good-Fair” or “Fair” in Appendix 4:
    - IRAC 3: cyfluthrin, zeta-cypermethrin

Action items

Research needs:

- What is the biology/etiology of yellow vine disease? Are there other insect vectors?
- Do we need to revise the squash bug threshold to account for yellow vine disease?

Regulatory needs:

- Capture is the primary insecticide for this insect; we must keep it.

Education needs:

- Spread the word and learn from growers: this is a vector for the bacterium that causes yellow vine disease.
- Reduce vector overwintering – promote cultural control practices.

Squash Vine Borer

Four-state rank: 1A (Common occurrence and difficult to control)

The squash vine borer, *Melittia cucurbitae* (Harris) (Lepidoptera: Sesiidae), tunnels in the vines of pumpkins and summer and winter squash; it rarely is found in cucumbers or melons and cannot complete its development except in squash or pumpkins.

Identification. The squash vine borer adult is a black and reddish moth called a clearwing moth because large portions of its hind wings lack scales. They are ¾- to 1-inch long, with a 1- to 1 ½-inch wing span. These moths are active during the daytime and superficially resemble wasps as they fly about. Larvae are yellowish-white with a brown head, 3 pairs of thoracic legs, and 5 pairs of fleshy abdominal prolegs that bear tiny hooks called crochets. Fully-grown larvae are about 1 inch long. Brownish pupae are slightly less than 1 inch long, and they are found in the soil inside a dark, silken cocoon.

Life Cycle. Squash vine borers overwinter as mature larvae or pupae within cocoons 1 ½ to 3 inches below the soil surface. Moths emerge and begin to mate and lay eggs in June and July in much of the Midwest (earlier, beginning in May, in southern Illinois and similar latitudes). Moths lay eggs singly at the base of plants or on stems and petioles, beginning when plants start to bloom or “run”. Larvae feed within stems or petioles for 2 to 4 weeks, leaving brown, sawdust-like frass (droppings) at the holes where they entered the stem. In southern Illinois squash vine borers pupate and produce a second flight of moths in late summer; in the north, larvae or pupae of the first (and only) generation remain in the soil through the winter.

Plant Injury. Tunneling within vines destroys water- and food-conducting tissues, reduce plant vigor and yield, and can kill the vines.

Non-Chemical Control

- Disking or plowing vines soon after harvest will bury and/or destroy overwintering cocoons, reducing moth populations within the field the following spring.
- Staggering plantings over several dates also allows some plantings to escape the heaviest periods of egg-laying.

Chemical Control

- Early detection of moths and initial damage is essential for timing insecticide applications. For insecticides to be effective, they must be applied before larvae enter stems or petioles. Scout for moths (pheromone lures and traps are available for monitoring flight periods) and look for entrance holes and frass as soon as plants begin to bloom or vine. Apply insecticides 5 to7 days after moths are first detected and at weekly intervals of 3 to 5 weeks, or begin when injury is first noted and make a second application a week later.
- Registered active ingredients rated as "Good" in Appendix 4:
    - IRAC 1A: carbaryl (Sevin 80 WSP, 80S, XLR+)
    - IRAC 3: bifenthrin (Capture 2 EC), esfenvalerate (Asana XL), fenpropathrin (Danitol 2.4 EC), permethrin (Ambush 25W, Pounce)
- Registered active ingredients rated as "Good-Fair" or "Fair" in Appendix 4:
    - IRAC 1B: malathion (Malathion 57 EC)
    - IRAC 2A: endosulfan (Endosulfan, Phaser 3EC, Thiodan)
    - IRAC 5: spinosad (Entrust, SpinTor, Success)
    - IRAC 21: rotenone
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" in Appendix 4:
    - IRAC 3: cyfluthrin, zeta-cypermethrin

Action items

Research needs:

- We need better ways to detect and determine when to spray (e.g., pheromone traps, temperature models).

Regulatory needs:

- No comments.

Education needs:

- No comments.

Twospotted Spider Mite

Four-state rank: 3B (Uncommon occurrence and intermediate ability to control)

Twospotted spider mites, *Tetranychus urticae* (Koch) (Acari: Tetranychidae), sometimes reach damaging levels in cucurbits during hot, dry weather. Such conditions favor population growth of spider mites and deter the success of their natural enemies.

Identification. Spider mites are tiny, about 1/50 inch in length, and oval in shape, so the details of their appearance are visible only with the aid of a magnifying glass or hand lens. Adult mites bear 8 legs (not 6 as in insects), and the twospotted spider mite is so named because adults have two large reddish to black marks on their abdomen. Females lay translucent, yellowish, spherical eggs; the first immature stage that hatches from these eggs has only 6 legs (and is called a larva); later stages all have 8 legs. Immature stages and adults secrete silken webbing on leaf surfaces, and heavily infested leaves may be covered by webbing.

Life Cycle. Twospotted spider mites overwinter as adult females that are resistant to cold temperatures. These overwintering mites are slightly reddish in color and are found in remnants of vegetation, primarily where they were feeding at the end of the summer and fall. Overwintering females may lay eggs during warm periods in the winter, and as temperatures rise in the spring, egg laying increases. Egg-to-adult generation time can be as short as 6 days, so many generations can develop each year and populations can increase dramatically in a short period of time. Spider mites disperse over long distances by "ballooning." They move to the tips of the upper leaves, spin a silken thread a few inches long, and wait for the wind to catch the thread and carry them long distances – often hundreds of yards or more.

Plant Injury. Spider mites pierce or abrade the surface of leaves to feed on plant sap. This injury causes leaves to turn pale or bronze, and severely injured leaves or plants may wilt, turn brown, and die.

Non-Chemical Control

- Clean mowing of weeds and grasses around fields in the fall and early summer can reduce the movement of mites into fields.
- Overhead irrigation also slows buildup of mite infestations, but irrigation may also favor development of foliar diseases and fruit rots.

Chemical Control

- Scout for spider mites throughout the season (and especially in hot, dry periods) by examining leaves for mites, eggs, and webbing. Use of a miticide may be necessary if populations increase over a 3- or 4-day period and leaves are beginning to discolor.
- Registered active ingredients rated as "Good" in Appendix 4:
    - IRAC 6: abamectin (Agri-Mek 0.15EC)
    - IRAC 25: bifenazate (Acramite 50WS)
- Registered active ingredients rated as "Good-Fair" or "Fair" in Appendix 4:
    - IRAC 3: bifenthrin (Capture 2 EC), fenpropathrin (Danitol 2.4 EC)
    - IRAC 20: dicofol (Kelthane 35)
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" in Appendix 4:
    - IRAC 10B: etoxazole

Action items

Research needs:

- No comments.

Regulatory needs:

- No comments.

Education needs:

- Scout along dusty roads since that is where the mites will show up first due to the drier environment.
- Do not mow the ditches when it's hot and dry since this will drive the spider mites out into the field.
- It is important to make two applications close together since spider mites have a short life cycle and you can not kill the eggs.

Whiteflies

Four-state rank: 3B (Uncommon occurrence and intermediate ability to control)

Greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), silverleaf whitefly, *Bemisia argentifolii* (Bellows and Perring), and additional whitefly species (Hemiptera: Homoptera: Aleyrodidae) occasionally infest cucurbits in the late summer and early fall in the Midwest, particularly in southern Illinois and in more southern latitudes.

Identification. Whitefly adults are small, about 1/16-inch long, with wings covered by a fine white waxy powder and held tent-like over the abdomen. Newly hatched immatures, called crawlers, are yellow, with red eyes and functional legs and antennae; later stages are flattened and scale-like; they do not move after inserting their mouthparts into leaves at the onset of feeding. Where whiteflies are numerous, their sugar-rich excretions called honeydew can coat leaf surfaces and serve as nutrition for the growth of dark sooty molds.

Life Cycle. Whiteflies do not overwinter very successfully outside of greenhouses in most of the Midwest, but populations tend to develop slowly in vegetable crops throughout the summer from small numbers that escape from greenhouses or are moved into the region on transplants. By late summer, population densities can reach damaging levels on late plantings of cucurbits and other vegetables. Whitefly adult females lay minute, eggs arranged in a semicircle on the underside of the leaves. These hatch into the crawler stage, and within a few days, the crawler inserts its mouthparts into plant tissue and "settles." It molts to form a nymph; nymphs are stationary, light green, flattened ovals with a fringe of short, white, waxy filaments radiating from the border of the body. Pupae develop from the nymphs and are similar in appearance, but have a few waxy filaments on their back. Egg-to-adult generation time is about 3 weeks during the hot conditions of mid to late summer.

Plant Injury. Whiteflies use piercing mouthparts to puncture leaf tissue and suck sap from cucurbits and other vegetables. Their direct feeding can reduce plant vigor, and they can transmit a group of plant viruses known as geminiviruses.

Non-Chemical Control

- None.

Chemical Control

- Whiteflies build to pest levels in late season in plantings where insecticide applications used to control other insect pests fail to kill whiteflies, usually because the whitefly population in that field is resistant to one or more of the commonly used insecticides. Where populations build, switching to a different insecticide labeled for whitefly control may be necessary.
- Registered active ingredients rated as "Good" in Appendix 4:
    - IRAC 7C: pyriproxyfen (Knack)
    - IRAC 9B: pymetrozine (Fulfill)
    - Not classified by IRAC: potassium salts (M-Pede)
- Registered active ingredients rated as "Good-Fair" or "Fair" in Appendix 4:
    - IRAC 2A: endosulfan (Endosulfan, Phaser 3EC, Thiodan)
    - IRAC 3: bifenthrin (Capture 2 EC), esfenvalerate (Asana XL), fenpropathrin (Danitol 2.4 EC),
    - IRAC 26: azadirachtin (Neemix)
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" in Appendix 4:
    - IRAC 4A: thiacloprid

Action items

<u>Research needs:</u>

- Do we have these geminiviruses in our states?

<u>Regulatory needs:</u>

- No comments.

<u>Education needs:</u>

- No comments.

WEEDS

Annual Broadleaf Weeds

Four-state rank: Varies by species, see Appendix 5.

Annual broadleaf weeds are some of the most problematic weeds in Midwestern cucurbit crops. Some examples of common annual broadleaf weeds include carpetweed (*Mollugo verticillata*), common cocklebur (*Xanthium strumarium*), eastern black nightshade (*Solanum ptycanthum*), horseweed/marestail (*Conyza canadensis*), jimsonweed (*Datura stramonium*), ladysthumb (*Polygonum persicaria*), common lambsquarters (*Chenopodium album*), ivyleaf morningglory (*Ipomoea hederacea*), pigweed/waterhemp complex (*Amaranthus* sp.), common purslane (*Portulaca oleracea*), common ragweed (*Ambrosia artemisiifolia*), giant ragweed (*Ambrosia trifida*), shepherd's-purse (*Capsella bursa-pastoris*), smallflower galinsoga (*Galinsoga parviflora*), prostrate spurge (*Euphorbia maculata*), velvetleaf (*Abutilon theophrasti*), Virginia pepperweed (*Lepidium virginicum*t) and wild buckwheat (*Polygonum convolvulus*). All annual broadleaf weeds reproduce by seed. Some large annual broadleaf weeds can produce over a hundred thousand seed. Annual broadleaf weed infestations occur from soil seedbanks (seeds which remain in the soil for years, "waiting" for the right conditions for germination). Many broadleaf weeds have dormant seeds that can survive years in the soil. Management of annual broadleaf weeds can prevent seed production and reduce soil seedbanks.

Identification. Annual broadleaf weeds need to be identified early in the seedling stage if postemergence practices are to be used for their control. There are several good guides that can help in identifying broadleaf weeds in the seedling stage. Annual broadleaf weeds also can be differentiated by their growth habit and when they start emerging. These weeds can be divided into those that are upright (jimsonweed, common lambsquarters, common cocklebur) and ones that are vining (morningglory, carpetweed, common purslane). The upright weeds overtop cucurbits and are very competitive. Some vining weeds, such as morningglory, also will overgrow cucurbit plants, reducing yield and making harvest difficult.

Life Cycle. Broadleaf weeds can be divided into winter and summer annuals. A common winter annual is horseweed. Also, plants in the mustard family [e.g., shepherd's-purse and Virginia pepperweed] are generally winter annuals. Winter annual broadleaf weeds emerge in late summer or fall and overwinter as a rosette of leaves. In the following spring, the plant produces a flowerstalk and seed and dies. Generally, winter annual broadleaf weeds are controlled by primary tillage such as disking and harrowing. Winter annual broadleaf weeds can be problems in reduced tillage systems. Summer annuals are the dominant group of broadleaf weeds in cucurbits. Summer annual weeds emerge in spring and summer, flower and produce seed, and die before the first fall frost. Some can produce seed in as short as three weeks after emergence.

The critical period for annual weed control in cucurbits is from planting through the beginning of fruit development. Also, weeds emerging with the crop are the most competitive. Annual broadleaf weeds also differ in their distribution in the Midwest. For example, smallflower galinsoga occurs in northern portions of Illinois while common cocklebur is more common in the southern portion of Illinois.

Non-Chemical Control

- In direct seeded pumpkins, rotary hoeing can provide control of some broadleaf weeds germinating with the crop. In transplanted cucurbits, plastic mulches can provide some weed control within the crop row and can improve crop competitiveness. Plastic mulch color needs to prevent photosynthetically active light from reaching the soil, so clear plastic mulch is not recommended. Broadleaf weeds emerging from crop holes in the plastic can be particularly competitive.
- Before vine formation, cultivation can be used to kill weeds between rows and bury weeds in rows of direct-seeded cucurbits.
- Stubble mulch for cover crops (followed by Roundup if using Rye or spring oats). More effective on the small-seeded broadleaves, but has effect on all weeds.

Chemical Control

- Annual broadleaf weeds in cucurbits are normally controlled with preemergence herbicides. Pigweeds and nightshades have been a problem to control. Preemergence herbicides must prevent broadleaf weed emergence up to cucurbit vine closure. After vine closure, emergence of broadleaf weeds is less likely.
- Stale seedbed treatments can reduce early season broadleaf weeds. Prepare the seedbed at least three weeks before planting. After broadleaf weeds have emerged, apply a nonselective herbicide, such as glyphosate or paraquat, and seed the cucurbit with minimal soil disturbance.
- Postemergent applications of halosulfuron can control some, small-sized broadleaf weeds in some cucurbit crops. Check the label for specific weeds controlled and the cucurbit crops to which postemergent applications can be made. Halosulfuron is an ALS-inhibitor and weed resistant biotypes can be a problem.
- Registered active ingredients rated as “Good” against at least 25% of the weeds in this group (see Appendix 5):
    - WSSA Group 2: halosulfuron (Sandea)
    - WSSA Group 9: glyphosate (Roundup, Credit, many)
    - WSSA Group 22: paraquat (Boa, Gramoxone Extra)
    - WSSA Group not specified: clove oil (Matran)
    - WSSA Group fatty acid: pelargonic acid (Scythe)
- Registered active ingredients rated as “Good”, “Good-Fair”, or “Fair” against at least 25% of the weeds in this group (see Appendix 5):
    - See above list rated as “Good”.
    - WSSA Group 3: ethalfluralin (Curbit 3 EC)
    - WSSA Group 13: clomazone (Command 3 ME)

    - WSSA Group 13, 3: clomazone + ethalfluralin (Strategy)
    - WSSA Group 14: carfentrazone-ethyl (Aim)
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" against at least 25% of the weeds in this group (see Appendix 5):
    - WSSA Group 2: imazamox, pyrithiobac-sodium
    - WSSA Group 14: lactofen, flumioxazin, fomesafen
    - WSSA Group 15: dimethenamid-P, S-metolachlor
    - WSSA Group not specified: acetic acid (vinegar)

Research needs:

- How to use cover crops to control weeds.
    - Integration with overall farm operation (other crops, land use decisions, etc.).
    - Integration with chemical control.
    - Does chemical burndown reduce the allelopathic effect?
    - Fertility, compaction aspects.
    - Reduction of diseases?
    - Which cover crop species are adapted to our states (what works in southern states may not work here).
    - Rodent problems with vegetative cover.

Regulatory needs:

- Need broadcast-applied, PRE and POST emergence broadleaf weed products; we have no use for products that allow only directed spray (row middles).
- Will experience a real problem since there are no good herbicide options for controlling eastern black nightshade and ground cherries.
- Need new chemistries to prevent/combat resistance problems in horseweed (marestail) and waterhemp.

Education needs:

- Identification and general emergence times/groups of weed species.
- Spread the word that cover crops provide weed and erosion control as well as cleaner pumpkins.
- Crop rotation is an important weed control measure; helps discourage populations of minor weeds.

Perennial Broadleaf Weeds

Four-state rank: 1A (Common occurrence and difficult to control)

Perennial broadleaf weeds include field bindweed (*Convolvulus arvensis*), dandelion (*Taraxacum officinale*), Canada thistle (*Cirsium arvenus*), and many others. They reproduce by vegetative structures, such as rhizomes, creeping root systems, tubers, and taproots, and seed. These weeds are extremely difficult to control in established cucurbit crops.

Identification. Each species will differ in its specific characteristics. Often management approaches will not differ between species and it is only necessary to identify the vegetative structures and develop approaches to control those structures.

Life Cycle. Some infestations of perennial weeds are established from seed, taking only four to six weeks for a seedling to produce a perennial structure. After emergence, the plants produce new shoots, followed by flowering and seed production, which is then followed by shoot death, leaving underground structures to overwinter. Often the most susceptible stage of the life cycle is during the bud-to-bloom stage, when food reserves are lowest.

Non-Chemical Control

- The best method to manage perennial broadleaf weeds in cucurbits is to prevent them from infesting fields. Carefully scout fields for perennial weeds. If perennial weeds are found before cucurbits are planted, then either eliminate the weeds or select another field.
- Perennial weeds can be eliminated by planting competitive crops or using cover crops such as cereal rye, Sudangrass, or buckwheat.
- Tillage has a mixed effect on perennial weeds, bringing vegetative structures to the soil surface where desiccation will kill them, but tillage can slice vegetative structures into small pieces and spread them.
- If perennial broadleaf weeds occur in cucurbit crops then several rescue approaches are possible. These include: 1) placing black plastic mulch over simple perennials such as dandelion; or 2) hand-removing the vegetative structures.

Chemical Control

- There are no selective herbicides registered for cucurbits that will control perennial broadleaf weeds.
- Perennial weeds can be eliminated by multiple treatments of nonselective herbicides containing glyphosate.
- Wipe or spot applications of glyphosate can be used as a rescue treatment.
- Registered active ingredients rated as “Good” against at least 25% of the weeds in this group (see Appendix 5):
    - None
- Registered active ingredients rated as “Good”, “Good-Fair”, or “Fair” against at least 25% of the weeds in this group (see Appendix 5):
    - WSSA Group 9: glyphosate (Roundup, Credit, many)
- “Pipeline” active ingredients rated as “Good”, “Good-Fair” or “Fair” against at least 25% of the weeds in this group (see Appendix 5):
    - WSSA Group 14: flumioxazin, fomesafen
    - WSSA Group not specified: acetic acid (vinegar)

Action items

- See “Annual Broadleaf Weeds” above.

Annual Grass Weeds

Four-state rank: Varies by species, see Appendix 5.

Annual grasses are some of the most competitive and common weeds of cucurbit crops in the Midwest. Examples of common annual grasses include barnyardgrass (*Echinochloa crus-galli*), large crabgrass (*Digitaria sanguinalis*), downy brome (*Bromus tectorum*), fall panicum (*Panicum dichotomiflorum*), the foxtail complex (*Setaria* spp.; giant foxtail, green foxtail), goosegrass (*Eleusine indica*), sandbur (*Cenchrus* spp.), shattercane (*Sorghum bicolor*) and witchgrass (*Panicum capillare*). All grass weeds are monocots that reproduce by prolific seed production. Grass weed infestations occur from soil seed banks. Management of annual grass weeds can prevent seed production and reduce soil seedbanks.

Identification. Annual grass weeds are best identified at the seedling stage. Mature grass weeds also differ in their seedheads (inflorescences), but at that stage it is too late for most management strategies. Identification books can aid in grass identification. Often, it is only necessary to differentiate between annual grasses and perennial grasses before initiating control.

Life Cycle. All annual grasses survive from year to year through seed. Generally, grass weed seeds only survive for a couple of years in the soil, unlike some broadleaf weed seed that can survive decades in the soil. Annual grass seedlings vary in their time of emergence. After emergence, the plants produce new shoots, followed by flowering and seed production, which is then followed by shoot death, leaving seed to overwinter. The critical period for annual weed control in cucurbits is from planting through the beginning of fruit development.

Non-Chemical Control

- In direct seeded cucurbits, such as pumpkins or squash, rotary hoeing can provide control of grass weeds germinating with the crop.
- In transplanted cucurbits, plastic mulches can provide some weed control within the crop row and can improve crop competitiveness. Plastic mulch color needs to prevent photosynthetically active light from reaching the soil, so clear plastic mulch is not recommended. Grass weeds emerging from crop holes in the plastic can be particularly competitive.
- Before vine formation, cultivation can be used to kill weeds between rows and bury weeds in rows of direct-seeded cucurbits.

Chemical Control

- Annual grass weeds in cucurbits are normally controlled with preemergence herbicides. Preemergence herbicides must prevent grass emergence up to cucurbit vine closure. After vine closure, emergence of grass weeds is less likely.
- Preemergence herbicides are sometimes applied under plastic mulch to control these weeds. The herbicide label must state that the herbicide can be used under plastic mulch or crop injury is likely to occur.

- Stale seedbed treatments can reduce early season grass weeds. Prepare the seedbed at least three weeks before planting. After the grass weeds have emerged, apply a nonselective herbicide, such as glyphosate or paraquat, and seed the cucurbit with minimal soil disturbance.
- Postemergent grass-active herbicides can be used in cucurbits to control emerged grass weeds, although crop vining can make application difficult.
- Registered active ingredients rated as "Good" against at least 25% of the weeds in this group (see Appendix 5):
    - WSSA Group 1: clethodim (Arrow 2EC, Prism, Select), sethoxydim (Poast)
    - WSSA Group 3: ethalfluralin (Curbit 3 EC), trifluralin (Treflan HFP)
    - WSSA Group 8: bensulide (Prefar 4E)
    - WSSA Group 9: glyphosate (Roundup, Credit, many)
    - WSSA Group 13: clomazone (Command 3 ME)
    - WSSA Group 13, 3: clomazone + ethalfluralin (Strategy)
    - WSSA Group 22: paraquat (Boa, Gramoxone Extra)
    - WSSA Group "fatty acid": pelargonic acid (Scythe)
- Registered active ingredients rated as "Good", "Good-Fair", or "Fair" against at least 25% of the weeds in this group (see Appendix 5):
    - See above list rated as "Good".
    - WSSA Group not specified: clove oil (Matran)
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" against at least 25% of the weeds in this group (see Appendix 5):
    - WSSA Group 2: imazamox
    - WSSA Group 15: dimethenamid-P, flufenacet, S-metolachlor
    - WSSA Group not specified: acetic acid (vinegar)

Action items

- See "Annual Broadleaf Weeds" above.

Perennial Grass Weeds

Four-state rank: Varies by species, see Appendix 5.

Perennial grass weeds can be divided into species growing best in cooler conditions of spring and fall (C-3 species such as quackgrass) and species growing best in warmer conditions of summer (C-4 species such as johnsongrass). Bemudagrass (*Cynodon dactylon*), and johnsongrass (*Sorghum halepense*) are most common in southern Illinois, and quackgrass (*Elymus repens*) and sorghum almum are more common in northern Illinois. Perennial grasses are produced by seed or by vegetative structures, such as rhizomes and stolons.

Identification. Newly emerging perennial grasses are identified by structures where the leaves attach to the plant stalk. Mature grass differ in seed heads, and successful control must be initiated prior to this stage. Noting the presence of rhizomes or stolons will differentiate perennial grass species from annual grass species.

Life Cycle. Some infestations of perennial grasses are established from seed, taking only four to six weeks for a seedling to produce a perennial structure. Plants can also emerge in the spring from underground reproductive structures. After emergence, the plants produce new shoots, followed by flowering and seed production, which is then followed by shoot death, leaving underground structures to overwinter.

Non-Chemical Control

- The best method to manage perennial grasses in cucurbits is to prevent them from infesting fields. Carefully scout fields for perennial grasses. If perennial grasses are found before cucurbits are planted, then either eliminate the weeds or select another field.
- Perennial weeds can be eliminated by planting competitive crops, or using cover crops such as cereal rye, Sudangrass, or buckwheat.
- Tillage has both positive and negative effects on perennial grasses. For example, tillage brings rhizomes to the soil surface where desiccation will kill them. However, tillage can also slice rhizomes into small pieces and spread them.

Chemical Control

- Perennial grass weeds can be managed by making multiple applications of postemergent, grass-active herbicides. Clethodim is good for quackgrass control. Preemergent grass herbicides such as bensulide, ethalfluralin, or clomazone may prevent perennial grass weed establishment from seed.
- Registered active ingredients rated as "Good" against at least 25% of the weeds in this group (see Appendix 5):
    - WSSA Group 1: clethodim (Arrow 2EC, Prism, Select)
- Registered active ingredients rated as "Good", "Good-Fair", or "Fair" against at least 25% of the weeds in this group (see Appendix 5):
    - See above list rated as "Good".
    - WSSA Group 9: glyphosate (Roundup, Credit, many)
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" against at least 25% of the weeds in this group (see Appendix 5):
    - None

Action items

- See "Annual Broadleaf Weeds" above.

Yellow Nutsedge

Four-state rank: 1A (Common occurrence and difficult to control)

Yellow nutsedge (*Cyperus esculentus*) is found throughout the Midwest, including Illinois. A related species, purple nutsedge (*C. rotundus*) is found in southern states and may be in southern Illinois. Nutsedge reproduces by tubers produced on stolons and seed. Nutsedge is extremely difficult to eradicate once established.

Identification. Yellow nutsedge has a grass-like appearance. The leaves are a yellow-green color and are more coarse than commonly occurring grasses. The stems of yellow nutsedge are triangular in cross section. Nutsedge has a distinct inflorescence (seed head), different from grasses. Small tubers also called "nutlets" are produced on the ends of stolons; this is the major method of spread for yellow nutsedge. These tubers primarily differentiate purple and yellow nutsedge. Unlike nutsedge, no perennial grasses found in the Midwest produce tubers.

Life Cycle. Some infestations of yellow nutsedge will establish from seed. Most infestations result from the tubers. Plants emerge in the spring from underground tubers, produce new shoots, followed by flowering and seed production, which is then followed by shoot death, leaving tubers to overwinter.

Non-Chemical Control

- The best method to manage yellow nutsedge in cucurbits is to prevent them from infesting fields. If yellow nutsedge is found before cucurbits are planted, either eliminate the weeds or select another field.
- Nutsedge is often found in compacted or wet areas of fields, and if these underlying problems are eliminated, nutsedge will be less of a problem.
- Tillage and other equipment can easily move tubers into fields not infested with nutsedge, so clean equipment before moving into new fields.
- Nutsedge can be a severe problem under plastic mulch because the sharp, emerging leaves can cut through the plastic.

Chemical Control

- Yellow nutsedge can be eliminated by making multiple applications of a nonselective herbicide containing glyphosate, or with halosulfuron over a period of years.
- Postemergent applications of halosulfuron can suppress yellow nutsedge, but this type of application is not labeled on all cucurbits. Postemergent grass-active herbicides do not affect nutsedge.
- Registered active ingredients rated as "Good" against at least 25% of the weeds in this group (see Appendix 5):
    - WSSA Group 2: halosulfuron (Sandea)
- Registered active ingredients rated as "Good", "Good-Fair", or "Fair" against at least 25% of the weeds in this group (see Appendix 5):
    - See above list rated as "Good".
    - WSSA Group 9: glyphosate (Roundup, Credit, many)
    - WSSA Group 22: paraquat (Boa, Gramoxone Extra)
- "Pipeline" active ingredients rated as "Good", "Good-Fair" or "Fair" against at least 25% of the weeds in this group (see Appendix 5):
    - WSSA Group 15: flufenacet, S-metolachlor

Action items

- See "Annual Broadleaf Weeds" above.

VERTEBRATE PESTS

Four-state rank: 1A (Common occurrence and difficult to control)

Mice, voles, birds, and primarily ground squirrels feed on seeds prior to and during germination. This feeding occurs in a wide range of tillage situations. Of primary concern are ground squirrels and voles.

Identification. The thirteen-lined ground squirrel, *Spermophilus tridecemlineatus*, is commonly called a "gopher" in the four-state area, particularly in Indiana and Illinois where pocket gophers do not occur or are present in only restricted geographical areas. This is a slender, brownish mammal, approximately 10 inches long with a bushy, 3-inch tail. Thirteen alternating light and dark stripes run the length of the body with 9 of these stripes extending over the back of the head and between the eyes. Five of the light colored stripes turn into spots along the back and extend to the posterior end of the body. The underside of the mammal is covered with light tan fur.

Common voles in the four-state area are the prairie vole, *Microtus ochrogaster*, meadow vole, *M. pennsylvanicus*, and pine vole, *M. pinetorum*. Voles are commonly called meadow mice or field mice. All three species are stocky rodents with short tails. They have blunt faces compared to house mice and are larger, ranging from 4 to 7 ½ inches long with gray to brown fur, depending on the species. The underside of each species is covered with gray fur.

Life Cycle. The thirteen-lined ground squirrel is active during the sunny part of the day, staying in the burrow during the night and on overcast days. Its 2 inch diameter burrow extends about 6 inches into the soil before splitting off into a series of passageways and chambers. Hibernation runs from September or early October into late March to early May in the four-state area. This animal goes into true hibernation with its body temperature dropping to within about 3 degrees C of the burrow air temperature. Mating begins about 2 weeks after emerging from the burrow in the spring and continues for about 2 weeks. A litter averages 10 (3 to 14) young, which are born 28 days after mating. Young are weaned and on their own from 6 to 12 weeks after birth, being sexually mature when 9 to 10 months old. Only one litter is produced per year. The thirteen-lined ground squirrel is omnivorous, with at least half of its diet consisting of insects, mice, earthworms, small birds, and each other. They also eat seeds, green shoots, flower heads, roots, vegetables, fruits, and cereal grains. They get most of their water from their food, and cache large quantities of seeds and grass which are eaten during periods of bad weather and in late autumn and early spring when food is scarce.

Voles are active day and night throughout the year; they do not hibernate. They make many tunnels and surface runways with several burrow entrances. Surface runways are 1 to 2 inches wide and appear as intersecting open-topped tunnels that are many feet long. Pine voles do not make surface runways. Burrows are also 1 to 2 inches in diameter. Voles can breed throughout the year, but do so primarily in spring and summer, having 1 to 5 litters per year. Litters average 3 to 6 young per litter but range from 1 to 11. Young are born 21 days after mating and are weaned within 21 days after

birth. Females are sexually mature in 35 to 40 days. Lifespans probably range from 2 to 16 months. Vole populations cycle, peaking every 2 to 5 years. These population peaks are not predictable, apparently being caused by a variety of factors. Voles are almost totally herbivorous. In late summer and fall, they store seeds, tubers, bulbs, and rhizomes. They will feed on bark of trees and shrubs, primarily in fall and winter. They occasionally eat snails, insects, and animal carrion. Both rodents are prey for many other animals including coyotes, foxes, snakes, hawks, and weasels. Because voles are also active at night, they are also prey for owls.

Non-Chemical Control

- Limited impact:
    - Consider using transplants instead of direct seeding.
    - Wire barriers.
    - Row tunnels.
    - Feed the hungry - give them seed?

Chemical Control

- Zinc phosphide (Pro ZAP)
    - For no-till crops.
    - Rating: Fair
    - Pellet form does not work as well.
- Thiram seed treatment
    - As an animal repellent, it creates a taste aversion to deter feeding. However, it does not appear to be a very good rodent repellent.

Action items

<u>Research needs:</u>

- Utilize or promote predators.
- Is there a product in the turf/landscape market that can be adopted?

<u>Regulatory needs:</u>

- We need a product; prefer seed treatment or in-furrow application.

<u>Education needs:</u>

- Unclear about state and federal laws protecting wildlife.

STRATEGIC ISSUES FOR PESTICIDES

In addition to the pumpkin industry priorities and pest-related action items mentioned in earlier chapters, the focus of this chapter is at-risk pest management scenarios due to potential product loss and/or the development of pesticide resistance. Furthermore, this chapter provides detailed information about each pesticide registered for use on pumpkins and provides input regarding products under consideration (those in the "pipeline").

As indicated in Appendices 3 through 5, pumpkin producers in Illinois, Indiana, Iowa and Missouri may battle 67 different pests each year, including 21 plant pathogens, 10 species of insects or insect relatives and 36 weed species. Though the occurrence of these pests vary by year and by region, it is important to recognize that there are relatively few non-chemical control tactics rated as "important tools" for battling these pests. The industry priorities listed earlier illustrate the desire that pumpkin producers have for improved and expanded non-chemical control options to help them further enhance their integrated pest management programs.

Considering the range of pests and the relative lack of highly effective non-chemical control tactics, it is not surprising that there are nearly 100 registered pesticide products available to control pumpkin pests (Table 4). Included in these registered products are 64 different active ingredients, which can be grouped into 50 distinct sites of action.

Table 4. Summary of registered pumpkin pesticide products, active ingredients, and sites of action.

	Registered		
	Fungicides	**Insecticides**	**Herbicides**
Registered products (premixes)	43 (4)	39 (0)	17 (1)
Active ingredients (biopesticides)	25 (4)	27 (5)	12 (2)
Distinct sites of action	21	19	10

A quick glance at Table 4, gives the impression that there are sufficient pesticides to manage pumpkin pests. However, close analysis of Appendices 3 through 5, reveals considerable gaps in pesticide efficacy as well as the potential for pesticide resistance issues. In some cases, particularly with weed control, the loss of a single pesticide would leave producers with no effective means of managing a particular pest species. More often, however, the consequences of losing a single pesticide are less obvious, but may substantially increase the risk of developing pesticide resistance.

AT-RISK PEST MANAGEMENT SCENARIOS

Following are the diseases, insects, and weeds which have no or few unique chemical control options at this time and thus, should be considered "at-risk" of not being controlled.

Diseases: There are no more than three registered sites of action considered to be effective (rated as Good, Fair-Good, or Fair) against these pathogens. Occurrence and ability to control rankings are listed in parentheses; see Appendix 3 for details:

- Bacterial leaf & fruit spot (1A)
- Plectosporium blight (1C)
- Angular leaf spot (2A)
- Fusarium crown and fruit rot (2A)
- Black rot (2B)
- Yellow vine disease (2B)
- Septoria leaf spot (2C)
- Root-knot nematodes (3A)
- Sclerotinia rot (3A)
- Bacterial wilt (3B)
- Scab (3C)

Insects: There are no more than three registered sites of action considered to be effective (rated as Good, Fair-Good, or Fair) against these insects. Occurrence and ability to control rankings are listed in parentheses; see Appendix 4 for details:

- Squash bug (1C)
- Seedcorn maggot (2B)

Weeds: There is one or no registered site of action considered to be effective (rated as Good, Fair-Good, or Fair) against these weeds. Nonselective herbicides were not considered. Occurrence and ability to control rankings are listed in parentheses; see Appendix 5 for details:

- Canada thistle (1A)
- Dandelion (1A)
- Field bindweed (1A)
- Giant ragweed (1A)
- Horseweed (Marestail) (1A)
- Johnsongrass (1A)
- Morningglory spp. (1A)
- Wild buckwheat (1A)
- Yellow nutsedge (1A)
- Jimsonweed (1C)
- Prostrate spurge (1C)
- Quackgrass (2A)
- Virginia pepperweed (2A)
- Sorghum almum (2C)
- Bermudagrass (3A)

After examining the pesticide options for each pest, a cut-point of "no more than three registered sites of action" was chosen for diseases and insects and "one or no registered site of action (excluding nonselective herbicides)" was chosen for weeds. These levels best illustrate the needs for each pest group. It is important to recognize that the pests listed above are not all equal in occurrence or importance and that not all are being actively/specifically managed.

In considering the potential for the development of pesticide resistance, one must consider the following factors:

- Are non-chemical tactics being used, such as crop rotation, tillage, resistant hosts, etc.?
- Are pesticides actually being used to control the pest?
- Are the pesticides acting on multiple or a single site of action?
- What is the frequency of applications per season?
- How many reproductive cycles per season does the pest complete?
- What is the impact of pesticides used on crops in rotation with pumpkin?

FUNGICIDES, BACTERICIDES, AND NEMATICIDES

This section includes pesticides which are registered for pumpkins. The information was obtained from product labels as well as from other sources listed in the "Acknowledgements" section at the end of this publication. The label information provided is believed to be accurate as of early 2005. However, label restrictions change often so be sure to read and follow the label which accompanies the product when purchased. Also included in this section are the "pipeline" pesticides; these are not registered for pumpkins, but registration is being considered by the registrant and/or by the Inter-regional Research Project #4 (IR-4) group. It is illegal and irresponsible to use a pesticide in a manner inconsistent with its label.

The terms RED (Reregistration Eligibility Decision), IRED (Interim Reregistration Eligibility Decision) and TRED (Report on FQPA Tolerance Reassessment Progress and [Interim] Risk Management Decision) are acronyms used by the U.S. Environmental Protection Agency to indicate reregistration or reassessment status of pesticides. For example, "IRED scheduled 3/2006" means that the EPA plans to issue an Interim Reregistration Eligibility Decision in March of 2006. It is during this process that current uses may be modified or eliminated to reduce overall product risk. To stay informed of the reregistration process for pesticide active ingredients, visit EPA's website at http://cfpub.epa.gov/oppref/rereg/status.cfm?show=rereg.

Fungicides, Bactericides, and Nematicides Registered for Pumpkins

- azoxystrobin (Amistar, Heritage, Quadris F)
    - Registration status: Section 3 (Post-FQPA, Reduced Risk)
    - Rate: Varies based on formulation (1.5 lbs a.i. per A*Y)
    - PHI: 1 day
    - REI: 4 hours
    - RUP or GUP: GUP
    - Human health concerns: None outstanding on label. Not likely to be carcinogenic to humans.
    - Environmental concerns: Toxic to freshwater and estuarine/marine fish and aquatic invertebrates. Groundwater concerns.
    - Resistance issues: Group 11. Tank-mixing with another fungicide is recommended.
    - Other:
        - Label should not allow back-to-back use.
        - Good tank-mix partner with copper.
        - Do not want to lose it; good rotational group with the triazoles.

- azoxystrobin + chlorothalonil (Quadris Opti)
    - Registration status: Section 3
    - Rate: 3.2 pts (1 lbs a.i. azoxystrobin and 15.75 lbs a.i. chlorothalonil per A*Y)
    - PHI: 1 day
    - REI: 12+ hours
    - RUP or GUP: GUP
    - Human health concerns: Causes moderate eye irritation. Allergic skin reaction. Not likely to be carcinogenic to humans. Group B (probable human carcinogen)

- Environmental concerns: Toxic to wildlife and freshwater and estuarine/marine fish and aquatic invertebrates. Ground and surface water concerns.
- Resistance issues: Groups 11, M5
- Other:
  - Arrived on the market at the end of 2004.
  - Preferred over Quadris alone.

- *Bacillus subtillis* GBO3 (Kodiak)
  - Registration status: Section 3 (Biopesticide)
  - Rate: 0.1-0.5 oz per cwt (seed treatment)
  - PHI: n/a
  - REI: n/a
  - RUP or GUP: GUP
  - Human health concerns: Causes skin irritation. May cause skin and lung sensitization.
  - Environmental concerns: None outstanding on label.
  - Resistance issues: FRAC Group not specified.
  - Other:
    - Seed treatment.
    - Accepted organic treatment.
    - Not aware of anyone using this product.

- *Bacillus subtillis* QST 713 (Serenade AS, Serenade ASO, Serenade Max, Serenade WP)
  - Registration status: Section 3 (Biopesticide)
  - Rate: varies based on formulation
  - PHI: 0 days
  - REI: 4 hours
  - RUP or GUP: GUP
  - Human health concerns: None outstanding to allergic skin reaction.
  - Environmental concerns: None outstanding on label.
  - Resistance issues: FRAC Group not specified.
  - Other:
    - Do not apply by air (except Serenade Max).
    - All are accepted organic treatments.
    - Not aware of anyone using this product; may have use in organic production.
    - Promoted septoria in one Iowa tomato trial.
    - Worked poorly against downy mildew in a pumpkin trial.

- boscalid + pyraclostrobin (Pristine)
  - Registration status: Supplemental label allows use on Pumpkin (Reduced risk).
  - Rate: 12.5-18.5 oz (74 oz formulation per A*Y)
  - PHI: 0 days
  - REI: 12 hours
  - RUP or GUP: GUP
  - Human health concerns: Causes moderate eye irritation. Pyraclostrobin: Data are inadequate for an assessment of human carcinogenic potential.
  - Environmental concerns: Toxic to fish and aquatic invertebrates. Surface water advisory.
  - Resistance issues: FRAC Group 7, 11
  - Other:

        - This product is valuable to the industry, but is hard to find. One of the best for powdery mildew and downy mildew.

- captan (Captan 400)
    - Registration status: Section 3 (RED signed 9/1999)
    - Rate: 1.5-2 fl. oz per cwt (seed treatment)
    - PHI: 0 days
    - REI: 0 hours
    - RUP or GUP: GUP
    - Human health concerns: Causes irreversible eye damage. May cause allergic skin reactions. Group B2 (probable human carcinogen).
    - Environmental concerns: Toxic to fish.
    - Resistance issues: FRAC Group M4
    - Other:
        - All processing pumpkin seed treated with Apron and captan, which gives much improved stands compared to untreated seed.
        - For jack-o-lantern pumpkins, the farmer decides whether seed is untreated or treated (thiram or captan are the only options).

- chlorothalonil (Bravo Ultrex, Bravo Weather Stick, Echo 720, Echo 90 DF, Echo Zn, Equus 720, Equus DF)
    - Registration status: Section 3 (RED signed 9/1998)
    - Rate: varies based on formulation (15.75 lbs a.i. per A*Y)
    - PHI: 0 days
    - REI: 12 hours plus 6.5 days of special eye protection provisions.
    - RUP or GUP: GUP
    - Human health concerns: Varies based on formulation. Causes substantial but temporary eye injury. May be fatal if inhaled. May be fatal if swallowed. May cause allergic skin reactions. Group B (probable human carcinogen).
    - Environmental concerns: Toxic to aquatic invertebrates and wildlife. Ground and surface water concerns.
    - Resistance issues: FRAC Group M5
    - Other:
        - A standard in the industry and an important resistance management tool.

- chlorothalonil + mefenoxam (Ridomil Gold Bravo)
    - Registration status: Section 3
    - Rate: 2-3 lbs (12 lbs formulation per A*Y)
    - PHI: 0 days
    - REI: 48 hours
    - RUP or GUP: GUP
    - Human health concerns: Corrosive. Causes irreversible eye damage. May be fatal if inhaled. May cause skin sensitation reactions. Chlorothalonil is listed as a Group B (probable human carcinogen). Mefenoxam is not likely to be carcinogenic to humans.
    - Environmental concerns: Toxic to fish.
    - Resistance issues: FRAC Group M5, 4
    - Other:
        - Good for downy mildew control.
        - Too expensive.

- copper (Tenn-Cop 5E, Champ Dry Prill, Champ Formula 2, Champ WP, Kocide 101, Kocide 2000, Kocide 4.5LF, Kocide DF, KOP-Hydroxide 50, KOP-Hydroxide 50W, KOP-Hydroxide 50WSP)
    - Registration status: Section 3 RED scheduled for 8/2006
    - Rate: varies based on formulation
    - PHI: 0 days
    - REI: 12 (Ten-Cop 5E), 48 (KOP-Hydroxide 50), all others 24 hours plus 7 days of special eye irritation provisions.
    - RUP or GUP: GUP
    - Human health concerns: Causes moderate eye irritation or irreversible eye damage. Allergic skin reaction. Group D (not classifiable as to human carcinogenicity).
    - Environmental concerns: Toxic to fish and aquatic organisms.
    - Resistance issues: FRAC Group M1
    - Other:
        - Can not control bacterial diseases without this product.
        - Phytophthora control was more successful with copper sulfate.
        - Inexpensive.

- copper sulfate (Cuprofix Disperss)
    - Registration status: Section 3 (RED scheduled for 5/2006)
    - Rate: 2.5 lbs
    - PHI: 0 days
    - REI: 24 hours
    - RUP or GUP: GUP
    - Human health concerns: Corrosive. Causes irreversible eye damage. Group D (not classifiable as to human carcinogenicity).
    - Environmental concerns: Toxic to fish and aquatic organisms.
    - Resistance issues: FRAC Group M1, M2
    - Other:
        - Can not control bacterial diseases without this.
        - Inexpensive, but packaging is a real pain (pilots will not use it).

- cymoxanil (Curzate 60DF)
    - Registration status: Section 3 (Post-FQPA)
    - Rate: 3.2 oz (28.8 oz formulation per A*Y)
    - PHI: 3 days
    - REI: 12 hours
    - RUP or GUP: GUP
    - Human health concerns: May be fatal if swallowed. Not likely to be carcinogenic to humans.
    - Environmental concerns: Toxic to fish and aquatic invertebrates.
    - Resistance issues: FRAC Group 27
    - Other:
        - Must tank-mix with a contact fungicide.
        - Good against downy mildew, but only fair against Phytophthora.

- cymoxanil + famoxadone (Tanos)
    - Registration status: Section 3
    - Rate: 8 oz (32 oz formulation per A*Y)

- PHI: 3 days
- REI: 12 hours
- RUP or GUP: GUP
- Human health concerns: Causes moderate eye irritation. Not likely to be carcinogenic to humans.
- Environmental concerns: Toxic to fish and aquatic invertebrates. Surface water advisory.
- Resistance issues: FRAC Group 27, 11
- Other:
  - Good against downy mildew. Second best against Phytophthora.
  - Registrant is changing rate to 10 oz, which is more effective.
  - Must tank-mix with a contact fungicide (copper or maneb).
    - Education: must mix-in copper first!

- dimethomorph (Acrobat)
  - Registration status: Supplemental label allows use on Pumpkin. (Post-FQPA)
  - Rate: 6.4 oz (32 oz formulation per A*Y)
  - PHI: 0 days
  - REI: 12 hours
  - RUP or GUP: GUP
  - Human health concerns: None outstanding on label. Not likely to be a human carcinogen.
  - Environmental concerns: None outstanding on label.
  - Resistance issues: FRAC Group 15
  - Other:
    - Not systemic.
    - Liquid formulation may be available in 2006.
    - East Coast producers are not fond of this product; this may be due to variation in isolates.
    - Best fungicide against Phytophthora. However, one must tank mix with another fungicide which is effective against Phytophthora; this approach makes use of this product expensive.

- fenamidone (Reason 500 SC)
  - Registration status: Section 3 (Reduced risk)
  - Rate: 5.5 oz (0.71 lb a.i. per A*Y)
  - PHI: 14 days
  - REI: 12 hours
  - RUP or GUP: GUP
  - Human health concerns: Causes moderate eye irritation. Not likely to be carcinogenic to humans.
  - Environmental concerns: Toxic to fish and aquatic invertebrates. Surface water advisory.
  - Resistance issues: FRAC Group 11
  - Other:
    - Do not know much about this product; should test it in our region.

- fludioxonil (Maxim 4FS)
  - Registration status: Section 3 (Reduced risk)
  - Rate: 0.08-0.16 fl oz per cwt seed
  - PHI: n/a

- REI: 12 hours
- RUP or GUP: GUP
- Human health concerns: Causes moderate eye irritation. Group D (not classifiable as to human carcinogenicity).
- Environmental concerns: Toxic to fish and aquatic organisms.
- Resistance issues: FRAC Group 12
- Other:
  - Not aware of anyone using this product; seed companies do not offer it as an option.
  - More expensive than the standard thiram and captan seed treatments.

- fosetyl-AL (Aliette WDG)
  - Registration status: Section 3 (RED signed 12/1990)
  - Rate: 2-5 lbs (see label for rate restrictions per A*Y)
  - PHI: 12 hours
  - REI: 12 hours
  - RUP or GUP: GUP
  - Human health concerns: Causes moderate eye injury. Not likely a human carcinogen.
  - Environmental concerns: Toxic to aquatic and estuarine invertebrates. ESA statement: "to protect endangered freshwater mollusks and their habitat, use no more than 3.75 lbs product per application (IL = Gallatin, Mercer, Whiteside; IA = Allamakee, Louisa, Muscatine; IN = Knox; MO = Butler, Cedar, Dunkin, Franklin, Jefferson, Ripley, and St. Louis.)
  - Resistance issues: FRAC Group 33
  - Other:
    - The only fully systemic fungicide.
    - Fair against downy mildew.
    - Does nothing in lab or field tests against Phytophthora.
    - More testing of the other (newer) phosphonate products.
      - Need to apply earlier than other fungicides to allow systemic acquired resistance to build up.

- maneb (Maneb 75 DF, Maneb 80WP, Manex)
  - Registration status: Section 3 (RED scheduled 9/2005; comment period ended recently [as of 3/18/05])
  - Rate: Varies based on formulation (12.8 lbs per A*Y)
  - PHI: 5 days
  - REI: 24 hours
  - RUP or GUP: GUP
  - Human health concerns: Varies; May cause irritation of eyes, nose, throat, and skin. Allergic skin reaction. B2 (Probable human carcinogen).
  - Environmental concerns: Toxic to fish.
  - Resistance issues: FRAC Group M3
  - Other:
    - Fair against downy mildew and Phytophthora
    - Registrant is considering registering mancozeb for pumpkin.
    - Inexpensive and works well; an important product alone and as a resistance management tool
      - Bravo is similar, but much more expensive

- mefenoxam (Apron XL LS)
    - Registration status: Section 3 (RED signed for metalaxyl on 09/1994. Reduced risk)
    - Rate: 0.085-0.64 fl oz/cwt seed
    - PHI: n/a
    - REI: 48 hours
    - RUP or GUP: GUP
    - Human health concerns: Causes substantial but temporary eye irritation. Not likely to be carcinogenic to humans.
    - Environmental concerns: Groundwater advisory.
    - Resistance issues: FRAC Group 4
    - Other:
        - Only controls oomycetes (*pythium* & *phytophthora*).
        - All processing pumpkin seed is treated with Apron and captan, which gives much improved stands compared to untreated.
        - For jack-o-lantern pumpkins, the farmer decides whether seed is untreated or treated (thiram or captan are the only options).

- mefenoxam (Ridomil Gold EC, Ultra Flourish)
    - Registration status: Section 3 (RED signed for metalaxyl on 09/1994. Reduced risk)
    - Rate: varies based on formulation
    - PHI: n/a (at planting)
    - REI: 48 hours
    - RUP or GUP: GUP
    - Human health concerns: Causes substantial but temporary eye injury. Not likely to be carcinogenic to humans.
    - Environmental concerns: Ground water advisory.
    - Resistance issues: FRAC Group 4
    - Other:
        - Very expensive.
        - Real valuable product, but with sporadic use.

- myclobutanil (Nova 40W)
    - Registration status: Section 3
    - Rate: 2.5-5 oz (0.6 lbs a.i. per A*Y)
    - PHI: 0 days
    - REI: 24 hours
    - RUP or GUP: GUP
    - Human health concerns: Causes substantial but temporary eye injury. Group E (Evidence of non-carcinogenicity to humans).
    - Environmental concerns: None outstanding on label.
    - Resistance issues: FRAC Group 3
    - Other:
        - Excellent for powdery mildew.
        - Important rotational product with strobilurins (FRAC Group 11).

- neem oil (Trilogy)
    - Registration status: Section 3 (Biopesticide)
    - Rate: 0.5-2%

    - PHI: Not specified.
    - REI: 4 hours
    - RUP or GUP: GUP
    - Human health concerns: Causes moderate eye irritation.
    - Environmental concerns: Hazardous to fish and aquatic invertebrates. Toxic to bees (direct exposure only).
    - Resistance issues: FRAC Group not specified.
    - Other:
        - Accepted organic treatment.
        - Not aware of anyone using this product; may have use in organic production.

- oxamyl (Vydate L)
    - Registration status: Section 3 (IRED signed 12/2000)
    - Rate: 1-2 gal (PRE or at-planting), 2-4 pts (foliar) (3 gal formulation per A*Y)
    - PHI: 1 day
    - REI: 48 hours
    - RUP or GUP: RUP due to acute toxicity and toxicity to birds and mammals.
    - Human health concerns: May be fatal or cause blindness if swallowed. May be fatal if absorbed through skin or inhaled. Group E (Evidence of non-carcinogenicity to humans).
    - Environmental concerns: Toxic to fish and aquatic invertebrates. Toxic to birds. Highly toxic to bees. Groundwater advisory.
    - Resistance issues: IRAC Group 1A
    - Other:
        - Not widely used.
        - Would not miss this product on pumpkins in this region.

- phosphorus acid (Agri-Fos, Fosphite, Phostrol)
    - Registration status: Section 3
    - Rate: Varies based on formulation (4.5 gal formulation per A*Y)
    - PHI: Not specified.
    - REI: 4 hours
    - RUP or GUP: GUP
    - Human health concerns: Causes moderate eye irritation.
    - Environmental concerns: Toxic to fish and aquatic organisms (Phostrol only). All others list nothing outstanding on label.
    - Resistance issues: FRAC Group 33
    - Other:
        - The only fully systemic fungicide.
        - Fair against downy mildew.
        - Does nothing in lab or field tests against Phytophthora.
        - More testing of the other (newer) phosphonate products.
            - Reports from southeast U.S. are good for Prophyt.
            - Need to apply earlier than other fungicides to allow systemic acquired resistance to build up. Agri-Fos indicates: “Apply within 7-10 days of infection”.

- potassium bicarbonate (Armicarb 100, Eco-Mate Armicarb "O")
    - Registration status: Section 3
    - Rate: 2.5-5 lbs per 100 gal
    - PHI: 0 days

- REI: 4 hours
- RUP or GUP: GUP
- Human health concerns: Causes moderate eye irritation.
- Environmental concerns: None outstanding on label.
- Resistance issues: FRAC Group not specified.
- Other:
  - Not aware of anyone using this product; may have use in organic production.

- potassium phosphite (Prophyt)
  - Registration status: Section 3
  - Rate: 2-4 pts
  - PHI: 0 days
  - REI: 4 hours
  - RUP or GUP: GUP
  - Human health concerns: Causes eye irritation.
  - Environmental concerns: None outstanding on label.
  - Resistance issues: FRAC Group 33
  - Other:
    - Not aware of anyone using this product; may have use in organic production.

- propamocarb hydrochloride (Previcur Flex)
  - Registration status: Section 3 (RED signed 9/1995)
  - Rate: 1.2 pts (4.5 lbs a.i. per A*Y)
  - PHI: 2 days
  - REI: 12 hours
  - RUP or GUP: GUP
  - Human health concerns: Causes moderate eye irritation. Allergic skin reaction. Not likely a human carcinogen.
  - Environmental concerns: None outstanding on label.
  - Resistance issues: FRAC Group 28
  - Other:
    - Unique mode of action.
    - Very new. Not tested in this region.
    - Must tank-mix with another downy mildew or Phytophthora fungicide.

- pyraclostrobin (Cabrio EG)
  - Registration status: Section 3 (Reduced risk)
  - Rate: 8-16 oz (64 oz formulation per A*Y)
  - PHI: 0 days
  - REI: 12 hours
  - RUP or GUP: GUP
  - Human health concerns: Causes moderate eye irritation. Data are inadequate for an assessment of human carcinogenic potential.
  - Environmental concerns: Toxic to fish and aquatic invertebrates. Surface water concerns.
  - Resistance issues: FRAC Group 11
  - Other:
    - Tank-mixing with another fungicide is recommended.
    - Reports from southeast U.S. indicate that it is slightly better than Quadris for downy mildew.
    - An important product, but would rather use Pristine.

- thiophanate-methyl (Topsin 4.5FL, Topsin 70 WSB, Topsin M WSB)
    - Registration status: Section 3 (RED signed 11/2004)
    - Rate: Varies based on formulation (2.1 lbs a.i. per A*Y)
    - PHI: 1 day
    - REI: 12 hours
    - RUP or GUP: GUP
    - Human health concerns: None outstanding to “Causes moderate eye irritation”. Likely to be carcinogenic to humans.
    - Environmental concerns: Toxic to fish.
    - Resistance issues: FRAC Group 1
    - Other:
        - Good for powdery mildew.
        - The 4.5 FL formulation is new (no data).
        - A rotation product for resistance management.

- thiram (42-S Thiram)
    - Registration status: Section 3 (RED signed 9/2004)
    - Rate: 4.5 fl oz per cwt of seed
    - PHI: n/a
    - REI: 24 hours
    - RUP or GUP: GUP
    - Human health concerns: Causes moderate eye irritation. Allergic skin reaction. Not likely to be carcinogenic to humans.
    - Environmental concerns: Toxic to fish
    - Resistance issues: FRAC Group M3
    - Other:
        - As an animal repellent, it creates a taste aversion to deter feeding. However, it does not appear to be a very good rodent repellent.
        - All processing pumpkin seed is treated with Apron and captan, which gives much improved stands compared to untreated.
        - For jack-o-lantern pumpkins, the farmer decides whether seed is untreated or treated (thiram or captan are the only options).

- trifloxystrobin (Flint)
    - Registration status: Section 3 (Post-FQPA. Reduced Risk)
    - Rate: 1.5-4 oz (8 oz formulation per A*Y)
    - PHI: 0 days
    - REI: 12 hours
    - RUP or GUP: GUP
    - Human health concerns: Causes moderate eye irritation. Allergic skin reaction. Not likely to be carcinogenic to humans.
    - Environmental concerns: Toxic to fish and aquatic invertebrates. Ground water Advisory.
    - Resistance issues: FRAC Group 11
    - Other:
        - Tank-mixing with another fungicide is recommended.
        - List of labeled diseases is shorter than for strobilurins; may not be as effective.

- triflumizole (Procure 50 WS)
    - Registration status: Section 3
    - Rate: 4-8 oz (40 oz formulation per A*Y)
    - PHI: 0 days
    - REI: 12 hours
    - RUP or GUP: GUP
    - Human health concerns: Causes moderate eye irritation. Allergic skin reaction. Group E (Evidence of non-carcinogenicity to humans).
    - Environmental concerns: Toxic to fish.
    - Resistance issues: FRAC Group 3
    - Other:
        - Similar (perhaps better) to Nova (myclobutanil) against powdery mildew.
        - Must alternate with another effective fungicide.

"Pipeline" Fungicide, Bactericide, and Nematicide Products:

- acibenzolar (Actigard, Blockade) [Syngenta]
    - Registration status: Pending (Post FQPA)
    - Disease spectrum (IR-4 comments): Induces resistance to blue mold, bacterial diseases, downy mildew, and sclerotinia.
    - Human health concerns: Not likely to be carcinogenic to humans.
    - Environmental concerns:
    - Resistance issues: FRAC Group P1
    - Other:
        - Did not control powdery mildew in Illinois pumpkin trials when applied as a foliar treatment.
        - In Indiana trials, on other cucurbits, this product worked well as a foliar treatment or as a transplant dip. However, it caused yield reductions when applied as a foliar treatment.

- *Ampelomyces quisqualis* isolate M-10 (AQ 10) [Ecogen]
    - Registration status: Pending (Post-FQPA. Biopesticide. Accepted organic treatment.)
    - Disease spectrum (IR-4 comments): Hyperparasite of the powdery mildew pathogen.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: FRAC Group not specified.
    - Other:
        - No comments.

- *Bacillus subtilis* (Taegro) [Taensa]
    - Registration status: Potential (Post-FQPA. Biopesticide)
    - Disease spectrum (IR-4 comments): Disease suppression.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: FRAC Group not specified.
    - Other:
        - No comments.

- benthiavalicarb (KIF-230) [K-I Chemical]
    - Registration status: Potential
    - Disease spectrum (IR-4 comments): Controls downy mildew and oomycete fungi, including *Phytophthora capsici*. Has both preventive and curative activity.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: FRAC Group U1
    - Other:
        - No comments.

- boscalid (BAS 510, Endura, Honor) [BASF]
    - Registration status: Pending (Reduced risk)
    - Disease spectrum (IR-4 comments): Manages powdery mildew, *Alternaria*, *Botrytis*, *Sclerotinia* and *Monillia*.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: FRAC Group 7
    - Other:
        - Good product for tomato foliar diseases.
        - Unique mode of action.
        - Would be a valuable addition.

- cyazofamid (Ranman 400 SC) [ISK Biosciences]
    - Registration status: Pending (Post-FQPA. Reduced risk)
    - Disease spectrum (IR-4 comments): *Oomycete* and *Plasmodiophoromycetes* (late blight and downy mildew).
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: FRAC Group 21
    - Other:
        - Illinois *Phytophthora* trials include 2 years on pepper & 1 year on pumpkin:
            - Not as good as Acrobat (dimethomorph).
            - A little systemic activity.
            - Short residual (~7 days).
        - Would be a valuable addition.

- cyflufenamid (NF-149, Pancho) [Nisso]
    - Registration status: Potential
    - Disease spectrum (IR-4 comments): Excellent activity on various powdery mildews and brown rots.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: FRAC Group not specified (Phenlyacetamid class)
    - Other:
        - No comments.

- cyprodinil + fludioxonil (Switch) [DuPont Crop Protection]
    - Registration status: Potential (Reduced risk)
    - Disease spectrum (IR-4 comments): downy mildew, late blight, *Phytophthora*, *Plasmopara*, *Pseudoperonospora*, *Albugo*.

    - Human health concerns: Cyprodinil is not likely to be carcinogenic to humans. fludioxonil is listed as a Group D (not classifiable as to human carcinogenicity).
    - Environmental concerns:
    - Resistance issues: FRAC Group 9, 12
    - Other:
        - Indiana trials: not impressed when used against downy mildew pathogen.

- ethaboxam (Guardian) [Sumitomo]
    - Registration status: Potential
    - Disease spectrum (IR-4 comments): Useful for grape downy mildew, potato and tomato late blight, pepper blight and cucumber downy mildew. Preventive and curative activity.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: FRAC Group U5
    - Other:
        - No comments.

- glutamic acid (AuxiGro) [Emerald Bioagriculture]
    - Registration status: Pending (Post-FQPA. Biopesticide)
    - Disease spectrum (IR-4 comments): Controls brown rot and suppresses shot hole.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: FRAC Group not specified.
    - Other:
        - No comments.

- ipconazole (Vortex) [Uniroyal, Crompton, Gustafson]
    - Registration status: Pending (Post-FQPA)
    - Disease spectrum (IR-4 comments): Protects against seedborne and soilborne fungi, which causes seed decay, damping off, and seedling blight.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: FRAC Group 3
    - Other:
        - No comments.

- kresoxim-methyl (Sovran, Cygnus) [BASF]
    - Registration status: Pending (Post-FQPA)
    - Disease spectrum (IR-4 comments): Mildews, septoria, rusts, scab, phomopsis, and black rot. Provides protectant, curative and eradicant control of powdery mildew.
    - Human health concerns: Likely to be carcinogenic to humans.
    - Environmental concerns:
    - Resistance issues: FRAC Group 11
    - Other:
        - Illinois: Have used this product in orchards; it is similar to other strobilurins.
        - Interested in testing for use in pumpkins.

- mepanipyrim (Frupica, Cockpit, TD-2448) [K-I Chemical]
    - Registration status: Potential
    - Disease spectrum (IR-4 comments): Controls Botrytis scab (Venturia spp.) and powdery mildew. Mostly a preventive material, but has curative properties. Unique mode of action/no cross-resistance.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: FRAC Group 9
    - Other:
        - No comments.

- milsana bioprotectant (Milsana Bioprotectant) [KHH BioScience]
    - Registration status: Pending (Post-FQPA. Biopesticide)
    - Disease spectrum (IR-4 comments): Induces phytoalexins which confer resistance to powdery mildew and other pathogens such as *Botrytis*.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: Biopesticide extract from giant knotweed (*Reynoutria sachalinensis*)
    - Other:
        - Indiana trials: Smelled bad and is not good against *Alternaria*.

- *Muscodor albus* (Arabesque) [AgraQuest]
    - Registration status: Potential (methyl bromide alternative. Biopesticide)
    - Disease spectrum (IR-4 comments): Fungus produces volatile compounds that are effective against plant pathogens and bacteria.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: FRAC Group not specified.
    - Other:
        - No comments.

- *Paecilomyces lilacinus* (Strain 251, Bio Act, Melo-Con WG) [Prophyta & Gustafson]
    - Registration status: Pending (Biopesticide)
    - Disease spectrum (IR-4 comments): Controls burrowing, root knot and cyst nematodes.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: FRAC Group not specified. Bio-nematicide
    - Other:
        - No comments.

- penthiopyrad (MFT 753) [Mitusi Chemical]
    - Registration status: Potential
    - Disease spectrum (IR-4 comments): Activity on strobilurin and DMI resistant diseases (grey mold, powdery mildew, apple scab, rusts, *Rhizoctonia*, *Botrytis*, etc.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: FRAC Group not specified (Carboxamide class).

- Other:
  - No comments.

- *Streptomyces lydicus* WYEC 108 (Actinovate, Actino-Iron) [Natural Industries]
  - Registration status: Pending (Post-FQPA. Biopesticide)
  - Disease spectrum (IR-4 comments): Controls soil borne plant root rots and damping-off fungi.
  - Human health concerns:
  - Environmental concerns:
  - Resistance issues: FRAC Group not specified.
  - Other:
    - No comments.

- SYP-L190 (common name unknown; possibly flumorth?) [Shenyang Research]
  - Registration status: Potential
  - Disease spectrum (IR-4): Effective against oomycete fungi, including downy mildew.
  - Human health concerns:
  - Environmental concerns:
  - Resistance issues: FRAC Group not specified. Cinnamic acid derivative (analog of dimethomorph).
  - Other:
    - No comments.

- SYP-Z071 (common name unknown; possibly enestroburin?) [Shenyang Research]
  - Registration status: Potential
  - Disease spectrum (IR-4 comments): Novel stroburlin fungicide, with similar control spectrum as with dimethomorph and azoxystrobin.
  - Human health concerns:
  - Environmental concerns:
  - Resistance issues: FRAC Group 11 (assumption)
  - Other:
    - No comments.

- tebuconazole (Folicur, Elite, Raxil) [Bayer Crop Science]
  - Registration status: Pending (RED is pre-FQPA, Tolerance reassessment was completed ~2000.)
  - Disease spectrum (IR-4 comments): Powdery mildew, rusts, smuts, bunts, apple scab, *Pyrenophora*, *Septoria*, *Coccomyces*, *Monilinia*, *Cercospora*, *Cercosporidium, Ceratocystis, Guignardia, Sclerotium, Rhizoctonia, Coccomyces, Rhynchosporium, Colletotrichum, Botrytis*, and *Rhizopus*.
  - Human health concerns: Group C (possible human carcinogen)
  - Environmental concerns:
  - Resistance issues: FRAC Group 3
  - Other:
    - Illinois: Controlled powdery mildew similar to thiophanate-methyl.

- V-10118 (common name unknown) [Valent]
  - Registration status: Potential
  - Disease spectrum (IR-4 comments): Effective on powdery mildew.

- Human health concerns:
- Environmental concerns:
- Resistance issues: “New chemistry & mode of action”
- Other:
  - No comments.

INSECTICIDES AND MITICIDES

See the "FUNGICIDES, BACTERICIDES, AND NEMATICIDES" section above for assistance in interpreting this section.

Insecticides & Miticides Registered for Pumpkins

- abamectin (Agri-Mek 0.15EC)
    - Registration status: Section 3
    - Rate: 8-16 fl oz (48 fl oz formulation per A*Y)
    - PHI: 7 days
    - REI: 12 hours
    - RUP or GUP: RUP due to toxicity to fish, mammals & aquatic organisms
    - Human health concerns: Substantial but temporary eye injury. Allergic skin reaction. Group E (Evidence of non-carcinogenicity for humans).
    - Environmental concerns: Toxic to fish and wildlife. Highly toxic to bees.
    - Resistance issues: Insecticide Resistance Action Committee (IRAC) Group 6
    - Other:
        - Good alternative for mites.
        - More expensive than Kelthane.

- azadirachtin (Azatin XL, Azatin XL Plus, Ecozin 3% EC, Neemix 4.5)
    - Registration status: Section 3 (Biopesticide. TRED scheduled for 8/2006)
    - Rate: Varies based on formulation
    - PHI: 0 days
    - REI: 4-12 hours
    - RUP or GUP: GUP
    - Human health concerns: Eye irritation to substantial but temporary eye injury.
    - Environmental concerns: Toxic to fish & aquatic invertebrates.
    - Resistance issues: IRAC Group 26
    - Other:
        - Neemix is an accepted organic treatment.
        - For organic growers, this is the only aphid & whitefly product.
        - Not effective enough and too expensive for conventional growers.

- *B.t. kurstaki* (Condor, Crymax, Deliver, Javelin WG, Lepinox WDG)
    - Registration status: Section 3 (Biopesticide. RED signed 9/1997)
    - Rate: Varies based on formulation
    - PHI: 0 days
    - REI: 4 hours (12 hours for Lepinox WDG)
    - RUP or GUP: GUP
    - Human health concerns: Varies - Substantial but temporary eye injury. Moderate eye irritation. Allergic skin reaction.
    - Environmental concerns: None outstanding on label.
    - Resistance issues: IRAC Group 11B2 (several different strains represented)
    - Other:
        - Deliver & Javelin WG are accepted organic treatments.
        - For organic growers, this only controls squash vine borer, but is not real effective.

- bifenazate (Acramite 50WS)
    - Registration status: Section 3 (Post-FQPA, Reduced Risk, OP Alternative)
    - Rate: 0.75 - 1 lb (1 application per year)
    - PHI: 3 days
    - REI: 12 hours
    - RUP or GUP: GUP
    - Human health concerns: Moderate eye irritation. Allergic skin reaction. Not likely to be carcinogenic to humans.
    - Environmental concerns: Toxic to fish. Toxic to bees (direct exposure only)
    - Resistance issues: IRAC Group 25
    - Other:
        - Must used softened water.
        - Good miticide.

- bifenthrin (Capture 2EC, Fanfare 2EC)
    - Registration status: Section 3
    - Rate: 2.6-6.4 fl oz (0.3 lb a.i. per A*Y)
    - PHI: 3 days
    - REI: 12 hours
    - RUP or GUP: RUP due to toxicity to fish & aquatic organisms
    - Human health concerns: Moderate eye irritation or substantial but temporary eye injury. Group C (possible human carcinogen)
    - Environmental concerns: Extremely toxic to fish & aquatic invertebrates. Highly toxic to bees.
    - Resistance issues: IRAC Group 3
        - There may be resistance in squash bug, but nothing reported.
    - Other:
        - The most important foliar product we have. Best squash bug product.
        - Broad-spectrum.
        - Not as good at high temperatures.

- bifenthrin + indole butyric acid (IBA) (Empower2)
    - Registration status: Section 3
    - Rate: 3.5-8.7 lb (0.3 lb a.i. per A*Y)
    - PHI: 3 days
    - REI: 24 hours
    - RUP or GUP: RUP due to toxicity to fish & aquatic organisms
    - Human health concerns: Moderate eye irritation. Group C (possible human carcinogen)
    - Environmental concerns: Extremely toxic to fish & aquatic invertebrates. Highly toxic to bees.
    - Resistance issues: IRAC Group 3
    - Other:
        - Not used. Nothing known about this product.

- carbaryl (Sevin 4F, Sevin 80 WSP, Sevin 80S, Sevin XLR+)
    - Registration status: Section 3 (IRED signed 6/2003)
    - Rate: Varies based on formulation (formulation per A*Y limits vary)
    - PHI: 3 days
    - REI: 12 hours

- RUP or GUP: GUP
- Human health concerns: Carbamate poisoning symptoms. Likely to be carcinogenic to humans.
- Environmental concerns: Extremely toxic to fish and estuarine invertebrates. Highly toxic to bees. May kill honey bees in substantial numbers.
- Resistance issues: IRAC Group 1A
- Other:
  - Inexpensive and valuable pumpkin product.
  - XLR + formulation is softer on bees.

- carbofuran (Furadan 4F)
  - Registration status: Use with pumpkins allowed in IA, IL, IN and MO by 24(c) only. 24(c) label expires 12/31/2006. (IRED scheduled 3/2006)
  - Rate: 2.4 fl oz per 1,000 ft of row
  - PHI: 53 days
  - REI: 48 hours
  - RUP or GUP: RUP due to acute oral and inhalation toxicity.
  - Human health concerns: Poisonous if swallowed or inhaled. Cholinesterase inhibitor. Not likely to be carcinogenic to humans.
  - Environmental concerns: Toxic to fish, birds, and other wildlife. Highly toxic to bees. Groundwater concerns.
  - Resistance issues: IRAC Group 1A
  - Other:
    - Cucumber beetle is the key target. Moderately effective for seedcorn maggot.
    - Soil application has systemic action (very water soluble).
    - Formulation sets up/settles out.
    - High human toxicity.
    - Much cheaper than Admire. If we lose carbofuran, we need cheaper Admire.

- chlorpyriphos (Lorsban 30 F, Lorsban 50-SL)
  - Registration status: Section 3
  - Rate: 2.0 to 2.75 fl. oz per cwt seed (varies based on formulation)
  - PHI: none
  - REI: none
  - RUP or GUP: GUP
  - Human health concerns: May be fatal if swallowed. Causes eye irritation. Group E (Evidence of non-carcinogenicity to humans).
  - Environmental concerns: Toxic to birds and wildlife and extremely toxic to fish and aquatic organisms. Exposed seed may be hazardous to birds and other wildlife.
  - Resistance issues: IRAC Group 1B
  - Other:
    - Limited usefulness because it is not systemic; it only protects seeds, not seedlings or larger plants.

- cyromazine (Trigard)
  - Registration status: Section 3
  - Rate: 2.66 oz (15.96 oz formulation per A*Y)
  - PHI: 0 days
  - REI: 12 hours

    - RUP or GUP: GUP
    - Human health concerns: Causes moderate eye irritation. Group E (Evidence of non-carcinogenicity to humans).
    - Environmental concerns: Ground water advisory.
    - Resistance issues: IRAC Group 17
    - Other:
        - No real interest for pumpkins.

- dicofol (Kelthane 35, Kelthane 50, Kelthane 50 WSP)
    - Registration status: Section 3 (IRED signed 9/1998)
    - Rate: Varies based on formulation
    - PHI: 2 days
    - REI: 12 hours (Kelthane 50 WSP is 48 hours)
    - RUP or GUP: GUP
    - Human health concerns: Corrosive. Irreversible eye injury. Skin contact may be hazardous. Allergic skin reaction. Group C (possible human carconigen).
    - Environmental concerns: Toxic to fish.
    - Resistance issues: IRAC Group 20
    - Other:
        - Moderate use; mites are not a real common pest.

- endosulfan (Endosulfan 3EC & 50WP, Phaser 3EC, Thiodan, Thionex 3EC & 50W)
    - Registration status: Section 3 (RED signed 7/2002)
    - Rate: Varies based on formulation (3 lbs a.i. per A*Y)
    - PHI: Varies - 1-2 days
    - REI: Varies - 24-48 hours
    - RUP or GUP: GUP
    - Human health concerns: Varies somewhat based on formulation. Fatal if swallowed. May be fatal if inhaled or absorbed through the skin. Causes irreversible eye damage. Not likely to be a human carcinogen.
    - Environmental concerns: Toxic to fish, birds, and other wildlife. Toxic to bees (direct exposure only). Phaser 3EC label directs user to “Contact your State Fish and Game Agency before using this product” regarding endangered species.
    - Resistance issues: IRAC Group 2A
    - Other:
        - Used some on aphids. Fair beetle product.
        - Good in hot weather.

- esfenvalerate (Asana XL)
    - Registration status: Section 3
    - Rate: 5.8-9.6 fl oz (0.25 lb a.i. per A*Y)
    - PHI: 3 days
    - REI: 12 hours
    - RUP or GUP: RUP due to toxicity to fish & aquatic organisms.
    - Human health concerns: None outstanding on label. Group E (Evidence of non-carcinogenicity for humans).
    - Environmental concerns: Extremely toxic to fish & aquatic invertebrates. Highly toxic to bees.
    - Resistance issues: IRAC Group 3
    - Other:
        - Some use; weaker but less expensive than Capture

        - Good on corn rootworm beetles, cucumber beetles, & squash vine borer.

- fenpropathrin (Danitol 2.4 EC)
    - Registration status: Section 3
    - Rate: 10.67-16 fl oz (0.8 lb a.i. per A*Y)
    - PHI: 7 days
    - REI: 24 hours
    - RUP or GUP: RUP due to toxicity to fish & aquatic organisms.
    - Human health concerns: Substantial but temporary eye injury. Skin irritation. Not likely to be carcinogenic to humans.
    - Environmental concerns: Extremely toxic to fish & aquatic invertebrates. Toxic to wildlife. Highly toxic to bees.
    - Resistance issues: IRAC Group 3
    - Other:
        - Recently labeled, so use is not real high.
        - Weaker but less expensive than Capture.
        - Good on corn rootworm beetles, cucumber beetles, & squash vine borer.
        - May not be quite as toxic as Asana towards beneficials.

- imidacloprid (Admire 2F)
    - Registration status: Section 3 (OP Alternative)
    - Rate: 16-24 fl oz (soil-applied) (0.5 lb a.i. per A*Y)
    - PHI: 21 days
    - REI: 12 hours
    - RUP or GUP: GUP
    - Human health concerns: None outstanding on label. Group E (Evidence of non-carcinogenicity for humans).
    - Environmental concerns: Toxic to wildlife and aquatic invertebrates. Highly toxic to bees. Ground water concern.
    - Resistance issues: IRAC Group 4A
    - Other:
        - As good or nearly as good as Furadan for control of cucumber beetles and seed corn maggots on seedlings (due to shorter residual?).
        - Very expensive; few are using it.
        - Considerable interest in using this or other neonicotinoids (e.g., clothianidin, thiacloprid, thiamethoxam) as seed treatments.

- kaolin (Surround WP)
    - Registration status: Section 3 (Biopesticide. First registered in 1998)
    - Rate: 12.5-100 lbs
    - PHI: 0 days
    - REI: 4 hours
    - RUP or GUP: GUP
    - Human health concerns: Causes moderate eye irritation.
    - Environmental concerns: None outstanding on label.
    - Resistance issues: IRAC Group not specified.
    - Other:
        - WP formulation registered for pumpkin.
        - Accepted as an organic treatment and offers organic producers some control of cucumber beetles.

- malathion (Malathion 57EC)
    - Registration status: Section 3 (IRED scheduled for 9/2005)
    - Rate: 1.5 pts
    - PHI: 3 days
    - REI: 12 hours
    - RUP or GUP: GUP
    - Human health concerns: None outstanding on label. Suggestive evidence of carcinogenicity, but not sufficient to assess human carcinogenic potential.
    - Environmental concerns: Toxic to fish, aquatic invertebrates, and aquatic life stages of amphibians. Highly toxic to bees (direct exposure only)
    - Resistance issues: IRAC Group 1B (Organophosphate)
    - Other:
        - Short-lived & inexpensive.
        - We can live without this product as long as we can keep other good aphid products.

- methoxyfenozide (Intrepid 2F)
    - Registration status: Section 3; Use with pumpkins allowed only by supplemental label. (Reduced risk/ OP alternative).
    - Rate: 4-10 fl oz (1 lb a.i. per A*Y)
    - PHI: 3 days
    - REI: 4 hours
    - RUP or GUP: GUP
    - Human health concerns: None outstanding on label. Not likely to be carcinogenic to humans.
    - Environmental concerns: Hazardous to aquatic invertebrates. Ground and surface water concerns.
    - Resistance issues: IRAC Group 18
    - Other:
        - Not used for pumpkins; no key targets.

- neem oil (Trilogy)
    - Registration status: Section 3 (Biopesticide)
    - Rate: 0.5-2%
    - PHI: Not specified.
    - REI: 4 hours
    - RUP or GUP:
    - Human health concerns: Causes moderate eye irritation.
    - Environmental concerns: Hazardous to fish and aquatic invertebrates. Toxic to bees (direct exposure only).
    - Resistance issues: IRAC Group not specified.
    - Other:
        - Accepted organic treatment.
        - Fair against aphids (a repellent); not consistent in other crops.
        - Better alternatives available for organic and conventional growers.

- oxamyl (Vydate L)
    - Registration status: Section 3 (IRED signed 12/2000)
    - Rate: 1-2 gal (PRE or at-planting), 2-4 pts (foliar) (3 gal formulation per A*Y)
    - PHI: 1 day

    - REI: 48 hours
    - RUP or GUP: RUP due to acute toxicity and toxicity to birds and mammals.
    - Human health concerns: May be fatal or cause blindness if swallowed. May be fatal if absorbed through skin or inhaled. Group E (Evidence of non-carcinogenicity to humans).
    - Environmental concerns: Toxic to fish and aquatic invertebrates. Toxic to birds. Highly toxic to bees. Groundwater advisory.
    - Resistance issues: IRAC Group 1A
    - Other:
        - Not widely used.
        - Would not miss this product on pumpkins in this region.

- oxydemeton-methyl (MSR Spray Concentrate)
    - Registration status: Section 3 (IRED signed 8/2002)
    - Rate: 1.5-2 pts (2 pts formulation per A*Y)
    - PHI: 14 days
    - REI: 48 hours
    - RUP or GUP: RUP due to reproductive effects.
    - Human health concerns: Moderate eye injury. May be fatal if swallowed, inhaled, or absorbed through the skin. Allergic skin reaction. Not likely to be carcinogenic to humans.
    - Environmental concerns: Toxic to fish and wildlife. Toxic to bees (direct exposure only).
    - Resistance issues: IRAC Group 1B
    - Other:
        - Slightly systemic.
        - Good against aphids.
        - Not widely used; would not miss this product unless we had a big aphid outbreak.

- permethrin (Ambush 25W, Pounce 25WP, Pounce 3.2EC)
    - Registration status: Section 3 (RED scheduled 6/2006)
    - Rate: varies by formulation (1.6 lbs a.i. per A*Y)
    - PHI: 0 days
    - REI: 12 hours
    - RUP or GUP: RUP due to toxicity to fish & aquatic organisms.
    - Human health concerns: Nothing outstanding to moderate eye injury. Suggestive evidence of carcinogenicity, but not sufficient to assess human carcinogenic potential.
    - Environmental concerns: Extremely toxic to fish & aquatic invertebrates. Highly toxic to bees.
    - Resistance issues: IRAC Group 3
    - Other:
        - Good usage.
        - Broad, effective, and less expensive than Capture.
        - Lots of generic permethrins.

- potassium salts (M-Pede)
    - Registration status: Section 3 (Biopesticide)
    - Rate: 1-2% v/v
    - PHI: 0 days

    - REI: 12 hours
    - RUP or GUP: GUP
    - Human health concerns: Substantial but temporary eye injury or skin irritation.
    - Environmental concerns: Hazardous to aquatic invertebrates.
    - Resistance issues: IRAC Group not specified.
    - Other:
        - Accepted organic product.
        - Good against aphids & whiteflies.
        - Some potential for crop injury during hot weather.

- pymetrozine (Fulfill)
    - Registration status: Section 3 (Post-FQPA. Reduced risk / OP alternative.)
    - Rate: 2.75 oz (5.5 oz formulation per A*Y)
    - PHI: 0 days
    - REI: 12 hours
    - RUP or GUP: GUP
    - Human health concerns: None outstanding on label. Likely to be carcinogenic to humans.
    - Environmental concerns: None outstanding on label.
    - Resistance issues: IRAC Group 9B
    - Other:
        - Not used; too specific & expensive.
        - Good against aphids & whiteflies.

- pyriproxyfen (Knack)
    - Registration status: Section 3; Use with pumpkins allowed only by supplemental label. (Reduced risk/ OP alternative.)
    - Rate: 8-10 fl oz (20 fl oz formulation per A*Y)
    - PHI: 7 days
    - REI: 12 hours
    - RUP or GUP: GUP
    - Human health concerns: Causes skin and eye irritation. Group E (Evidence of non-carcinogenicity for humans).
    - Environmental concerns: Toxic to fish and aquatic invertebrates.
    - Resistance issues: IRAC Group 7C
    - Other:
        - Not used; too specific & expensive.
        - Good against whiteflies.

- rotenone (could not find agricultural label)
    - Registration status: Section 3 (RED scheduled for 5/2006)
    - Rate: 1 lbs treats about per 400 ft of row (foliar dust)
    - PHI: none listed
    - REI: none listed (no WPS language)
    - RUP or GUP: GUP
    - Human health concerns: None outstanding on label. Group E (Evidence of non-carcinogenicity for humans).
    - Environmental concerns: Extremely toxic to fish.
    - Resistance issues: IRAC Group 21
    - Other:
        - No longer accepted by National Organic Program.

        - Fair to good corn rootworm and cucumber beetle product.
        - Would not miss this product for use in pumpkins in these states.

- spinosad (Entrust, GF-120 Naturalyte Fruit Fly Bait, SpinTor 2SC, Success)
    - Registration status: Section 3 (Post-FQPA, Reduced Risk / OP alternative.)
    - Rate: varies based on formulation (0.45 lb a.i. per A*Y)
    - PHI: 3 days (no PHI listed for GF-120 Naturalyte Fruit Fly Bait)
    - REI: 4 hours
    - RUP or GUP: GUP
    - Human health concerns: None outstanding to moderate eye irritation. Not likely to be carcinogenic to humans.
    - Environmental concerns: Toxic to bees (for 3 hrs). Toxic to aquatic invertebrates.
    - Resistance issues: IRAC Group 5
    - Other:
        - Entrust is listed as an accepted organic treatment and is valuable for organic growers.
        - Fair against corn rootworm, cucumber beetles, pickleworm and squash vine borer.

- thiamethoxam (Platinum)
    - Registration status: Section 3 (Reduced risk/ OP alternative.)
    - Rate: 5-8 fl oz per A (soil application; convert to linear feet) (0.125 lb a.i. per A*Y)
    - PHI: 30 days
    - REI: 12 hours
    - RUP or GUP: GUP
    - Human health concerns: None outstanding on label. Likely to be carcinogenic to humans.
    - Environmental concerns: Toxic to wildlife. Highly toxic to aquatic invertebrates. Surface and ground water advisories.
    - Resistance issues: IRAC Group 4A
    - Other:
        - Need to expand the label to include cucumber beetles. On March 9, 2005, a 2(ee) label (EPA #100-939) was approved for this use in eight eastern states.
        - Considerable interest in using this or other neonicotinoids (e.g., clothianidin, imidacloprid, thiacloprid) as seed treatments.

"Pipeline" Insecticide and Miticide Products:

- bistrifluron (DBI-3204) [Dongbu Hamnong Chemical]
    - Registration status: Potential
    - Insect spectrum (IR-4 comments): Active against lepidopteran pests, whitefly.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: IRAC Group 15? (Benzoylphenyl urea class)
    - Other:
        - No comments.

- chromafenozide (Matric) [Nippon Kayahu, Sankyo]
    - Registration status: Potential
    - Insect spectrum (IR-4 comments): Specific to lepidopteron pests.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: IRAC Group 18
    - Other:
        - No comments.

- clothianidin (Poncho, Clutch) [Bayer Crop Science (seed) Arvesta (soil & foliar markets)]
    - Registration status: Potential (Post-FQPA. Reduced Risk and OP replacement)
    - Insect spectrum (IR-4 comments): Contact and stomach activity. When applied to soil there is activity on corn rootworms, cutworms, wireworms, cinch bugs, white grubs and flea beetles. Foliar activity on plum curculio, aphids, leafhoppers, apple maggot, leafminers, leaf rollers, codling moth, and pear psylla.
    - Human health concerns: Not likely to be a human carcinogen.
    - Environmental concerns:
    - Resistance issues: IRAC Group 4A
    - Other:
        - Interested in pursuing this product as a seed treatment.

- cyfluthrin (Baythroid, Renounce 20 WP) [Bayer Crop Science]
    - Registration status: Pending
    - Insect spectrum (IR-4 comments): Controls cabbage looper, potato leafhopper, Colorado potato beetle, European corn borer, flea beetles, potato tuberworm, citrus thrips.
    - Human health concerns: Not likely to be carcinogenic to humans.
    - Environmental concerns:
    - Resistance issues: IRAC Group 3
    - Other:
        - No comments.

- dinotefuran (Stackle) [Mitsui Chemical/ Valent]
    - Registration status: Pending (Post-FQPA. Reduced Risk Product and OP alternative)
    - Insect spectrum (IR-4 comments): Effective on aphids, thrips, leaf miners, cabbage worm, diamond back moth, stink bugs, mealy bugs, whitefly, and flea beetles.
    - Human health concerns: Not likely to be a human carcinogen.
    - Environmental concerns:
    - Resistance issues: IRAC Group 4A
    - Other:
        - No comments.
        - Federal Register: March 23, 2005 (Volume 70, Number 55)] [Page 14535-14546] – tolerances were established on cucurbits.

- emamectin benzoate (Proclaim, Strategy, Denim) [Syngenta]
    - Registration status: Potential (OP alternative)
    - Insect spectrum (IR-4 comments): Effective on larval lepidoptera (beet/fall armyworms, cabbage webworm, corn earworm, imported cabbage worm, cabbage looper) and leafminers.
    - Human health concerns: Not likely to be a human carcinogen.
    - Environmental concerns:
    - Resistance issues: IRAC Group 6
    - Other:
        - No comments.

- etofenprox (Trebon) [Mitsui Chemical]
    - Registration status: Potential
    - Insect spectrum (IR-4 comments): Broad spectrum: rice bugs, leafhoppers, weevils, armyworms.
    - Human health concerns: Group C (possible human carconigen).
    - Environmental concerns:
    - Resistance issues: IRAC Group 3
    - Other:
        - No comments.

- etoxazole (Zeal) [Valent, Yashima]
    - Registration status: Potential (Post-FQPA. Reduced Risk)
    - Insect spectrum (IR-4 comments): Manages mites (*Panonychus* spp. and *Tetranychus* spp.) by inhibition of molting. Effective on the egg, larval, and nymph stages.
    - Human health concerns: Not likely to be carcinogenic to humans.
    - Environmental concerns:
    - Resistance issues: IRAC Group 10B
    - Other:
        - No comments.

- flonicamid (Turbine 50 WG) [FMC and ISK]
    - Registration status: Pending (Reduced risk. OP Replacement)
    - Insect spectrum (IR-4 comments): Effective against aphids, thrips, leafhoppers, plant bugs and other sucking insect pests. Provides rapid antifeeding activity. Non-toxic to beneficials.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: IRAC Group 9C
    - Other:
        - No comments.

- flufenzin (trade name unknown) [Chinoin]
    - Registration status: Potential
    - Insect spectrum (IR-4 comments): Acaricide
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: IRAC Group not specified.
    - Other:

        - No comments.

- indoxacarb (Avaunt, Steward) [DuPont Crop Protection]
    - Registration status: Pending (Post-FQPA. Reduced Risk and OP Replacement)
    - Insect spectrum (IR-4 comments): Controls most major Lepidoptera pest species. Also activity on leafhoppers, tarnished plant bug, grasshoppers, mole crickets and some beetles. Soft on beneficials.
    - Human health concerns: Not likely to be carcinogenic to humans.
    - Environmental concerns:
    - Resistance issues: IRAC Group 22
    - Other:
        - No comments.

- *Metarhizium anisopliae* (Taerain) [Earth Bio Science]
    - Registration status: Pending (Post-FQPA. Biopesticide)
    - Insect spectrum (IR-4 comments): Controls whitefly, thrips, and mites.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: IRAC Group not specified.
    - Other:
        - No comments.

- pyridaben (Nexter 75 WP, Sanmite) [BASF]
    - Registration status: Potential
    - Insect spectrum (IR-4 comments): Activity on mites and whiteflies. A new class of insecticide offering long term residual control. Good for IPM/resistance management.
    - Human health concerns: Group E (Evidence of non-carcinogenicity for humans).
    - Environmental concerns:
    - Resistance issues: IRAC Group 21
    - Other:
        - No comments.

- spiromesifen (Oberon 2 SC, BSN 2060) [Bayer CropScience]
    - Registration status: Pending
    - Insect spectrum (IR-4 comments): Effective against whitefly and mites. Juvenile stages are more susceptible than adults. Difficult to control the pupal stage.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: IRAC Group 23
    - Other:
        - No comments.

- thiacloprid (Calypso 4 Flowable, Alanto, Bariard) [Bayer Crop Science]
    - Registration status: Potential (Post-FQPA)
    - Insect spectrum (IR-4 comments): Broad spectrum systemic control of sucking and chewing insect pests including aphids, whiteflies, leaf hoppers, plant bugs, pear psylla, weevils, fruit flies, oriental fruit moth, leafminers, and codling moth. Very safe to bees.
    - Human health concerns: Likely to be carcinogenic to humans.

    - Environmental concerns:
    - Resistance issues: IRAC Group 4A
    - Other
        - Interested in pursuing this product as a seed treatment.

- thiocyclam (Evisect) [Arvesta & Nippon Kayaku]
    - Registration status: Potential
    - Insect spectrum (IR-4 comments): Not specified.
    - Human health concerns: Group D (not classifiable as to human carcinogenicity).
    - Environmental concerns:
    - Resistance issues: IRAC Group not specified.
    - Other:
        - No comments.

- tolfenpyrad (Hachihachi) [Nichino America]
    - Registration status: Potential
    - Insect spectrum (IR-4 comments): Effective against diamondback moths, other moths, thrips and aphids.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: IRAC Group 21
    - Other:
        - No comments.

- zeta-cypermethrin (Fury, Mustang, Mustang Maxx) [FMC]
    - Registration status: Pending (OP alternative. RED scheduled for 5/2006.)
    - Insect spectrum (IR-4 comments): Controls cutworms, thrips, armyworms, etc.
    - Human health concerns: Group C (possible human carcinogen).
    - Environmental concerns:
    - Resistance issues: IRAC Group 3
    - Other:
        - Registration may help drive down the price of other pyrethroids (this will be true of other pipeline product a.i.'s)
        - Indiana: Worked well in trials.
        - Less heat-sensitive than Capture.

HERBICIDES

See the "FUNGICIDES, BACTERICIDES, AND NEMATICIDES" section above for assistance in interpreting this section.

Herbicides Registered for Pumpkins

- bensulide (Prefar 4E)
    - Registration status: Section 3 (IRED signed 9/2000)
    - Rate: 5-6 qts (PPI) (6 qts formulation per A*Y)
    - PHI: n/a
    - REI: 12 hours
    - RUP or GUP: GUP
    - Human health concerns: Causes moderate eye irritation. Not likely to be carcinogenic to humans.
    - Environmental concerns: Toxic to fish and aquatic invertebrates. Highly toxic to bees (direct exposure only)
    - Resistance issues: WSSA Group 8
    - Other:
        - Conflicting crop list on label, but many states are recommending it for pumpkins. Illinois (J. Masiunas) does not recommend Prefar for pumpkin (not directly mentioned on label; other choices are better for grass control).
        - Do not apply by air.
        - Not used. High use rates, inconsistent grass control, and carryover problems.

- carfentrazone-ethyl (Aim)
    - Registration status: Section 3 (Reduced risk. Post-FQPA.)
    - Rate: Label provides conflicting rate information for hooded applications.
    - PHI: No PHI listed for hooded applications.
    - REI: 12 hours
    - RUP or GUP: GUP
    - Weed spectrum: Numerous broadleaf weeds, including cocklebur and water hemp. POST application.
    - Human health concerns: Causes moderate eye irritation. Not likely to be carcinogenic to humans.
    - Environmental concerns: Very toxic to algae and moderately toxic to fish.
    - Resistance issues: WSSA Group 14
    - Other:
        - Labeled for use with pumpkins (crop group 9) as a Hooded Sprayer Application.
        - As a directed-POST spray, this product is only useful for spot treatments and resistance management.
        - Illinois (J. Masiunas) evaluated carfentrazone on pumpkin and found that injury was too great for an "over-the-top" application.

- clethodim (Arrow 2EC, Prism, Select 2 EC)
    - Registration status: Section 3
    - Rate: varies by formulation (0.5 lb a.i. per A*Y)
    - PHI: 14 days
    - REI: 24 hours

- RUP or GUP: GUP
- Human health concerns: Causes substantial but temporary eye injury. Allergic skin reactions.
- Environmental concerns: None outstanding on label.
- Resistance issues: WSSA Group 1
- Other:
  - Good annual, but not perennial grass product.
  - Would an increased label rate make this product more useful against perennial grasses? If so, consider that an application of a POST herbicide to vining pumpkins is difficult.

- clomazone (Command 3 ME, Commit 3ME)
  - Registration status: Section 3
  - Rate: 0.67-2 pts (PRE) (1.25 lb a.i. per A*Y)
  - PHI: 45 days
  - REI: 12 hours
  - RUP or GUP: GUP
  - Human health concerns: Causes eye irritation. Allergic skin reaction. Not likely to be carcinogenic to humans.
  - Environmental concerns: None outstanding on label.
  - Resistance issues: WSSA Group 13
  - Other:
    - Not registered for use on jack-o-lantern pumpkins. Manufacturer is not willing to allow use on jack-o-lantern pumpkins due to experience with crop damage lawsuits and differential cultivar sensitivity.
    - Do not apply by air.
    - Major deficiency is pigweed/waterhemp, carpetweed, and eastern black nightshade.
    - Not being sold by FMC in the Midwest. UAP may be selling it?

- clomazone + ethalfluralin (Strategy)
  - Registration status: Section 3
  - Rate: 2-6 pts (PRE)
  - PHI: n/a PRE
  - REI: 24 hours
  - RUP or GUP: GUP
  - Human health concerns: Causes moderate eye irritation. Clomazone is listed as "Not likely to be carcinogenic to humans". Ethalfluralin is listed as a Group C (possible human carcinogen).
  - Environmental concerns: Toxic to fish and aquatic invertebrates.
  - Resistance issues: WSSA Group 13, 3
  - Other:
    - Do not apply by air.
    - Core grass herbicide for jack-o-lantern market.
    - Increasing the clomazone component rate to improve grass control would increase the cost and carryover potential; see above comments regarding "clomazone" alone.
    - Major deficiency is still similar to clomazone.

- clove oil (Matran EC) [EcoSmart/Bioganic]
  - Registration status: Biopesticide. "Bioganic represents that this product qualifies for exemption from registration under FIFRA. Under section 25(b) of FIFRA "minimum risk" pesticides are exempted from EPA registration because such contain compounds that are classified as Generally Regarded as Safe (GRAS). Clove oil is listed on USEPA 40 CFR 152.25(g)(1).
  - Rate: 5-7 gallons (POST-directed)
  - PHI: n/a
  - REI: When residue is dry .
  - RUP or GUP: GUP
  - Human health concerns: Exposure to clove oil may cause skin, eye, and nasal passage irritation, dizziness, headache or nausea.
  - Environmental concerns: None known, but avoid entry into aquifers.
  - Resistance issues: WSSA Group "unknown"
  - Other:
    - Many annual broadleaf weeds and grasses. Works by desiccation and re-growth can be a problem.
    - OMRI-approved and USDA National Organic Program-compliant.
    - Minimum risk pesticide.
    - Must be applied between rows of pumpkins. Contact with the crop will cause injury.

- ethalfluralin (Curbit 3 EC)
  - Registration status: Section 3 (TRED scheduled 4/2006)
  - Rate: 3-4.5 pts (PRE)
  - PHI: n/a PRE
  - REI: 24 hours
  - RUP or GUP: GUP
  - Human health concerns: Causes irreversible eye damage and skin burns. Skin sensitation reactions. Group C (possible human carcinogen).
  - Environmental concerns: Toxic to fish and aquatic invertebrates.
  - Resistance issues: WSSA Group 3
  - Other:
    - Volatility is a problem (needs rainfall/irrigation for incorporation)
    - Poor to fair against waterhemp and nightshade.
    - Potential for pumpkin injury if herbicide contacts germinating seed or emerging seedling. Injury potential is increased in cold, wet weather.

- glyphosate (Credit Systemic, Roundup WeatherMAX)
  - Registration status: Section 3 (Reduced risk. RED signed 9/1993.)
  - Rate: varies (burndown treatments)
  - PHI: n/a PRE
  - REI: Varies, 4-12 hours
  - RUP or GUP: GUP
  - Human health concerns: Causes moderate eye irritation. Group E (Evidence of non-carcinogenicity to humans).
  - Environmental concerns: None outstanding on label.
  - Resistance issues: WSSA Group 9
  - Other:
    - One of few options for spot applications to control certain perennial weeds.
    - Used for stale seedbed treatments prior to pumpkin emergence.

        - Roundup Ready pumpkins:
            - Jack-o-lantern producers would like to see this as an option. However, this option is unlikely because of range of cultivars used for jack-o-lantern production.
            - Not an option and not acceptable for processors.

- halosulfuron (Sandea)
    - Registration status: Section 3 (Methyl Bromide alternative)
    - Rate: 0.5-1 oz (PRE or POST) (1 oz formulation per A*Y)
    - PHI: 30 days
    - REI: 12 hours
    - RUP or GUP: GUP
    - Human health concerns: Causes moderate eye irritation. Not likely a human carcinogen.
    - Environmental concerns: None outstanding on label.
    - Resistance issues: WSSA Group 2
    - Other:
        - Label allows use on jack-o-lantern and processing pumpkins.
        - Do not apply by air.
        - Caution regarding interaction with organophosphate insecticides.
        - The only POST broadleaf herbicide. Timing issues – can be phytotoxic.
        - Good preemergence product; less phytotoxicity. A standard broadleaf herbicide.
        - Excellent cocklebur & nutsedge (POST) product.
        - No control of waterhemp. Fair for pigweed (better on smaller weeds).
        - Crop rotational restrictions can be a limitation. However, maintaining the use rate is more important than changing the crop rotation restrictions. Many common rotational crops are listed with reasonable rotation restrictions. The “all other crops” category is the most unreasonable with 36 months.

- paraquat (Boa, Gramoxone Max)
    - Registration status: Section 3 (RED signed 8/1997)
    - Rate: varies (burndown, POST-directed, and stale seedbed treatments)
    - PHI: n/a PRE
    - REI: 12 hours
    - RUP or GUP: RUP due to acute toxicity.
    - Human health concerns: May be fatal if swallowed. Fatal if inhaled. Substantial but temporary eye injury. Group E (Evidence of non-carcinogenicity to humans).
    - Environmental concerns: Toxic to wildlife and nontarget crops and plants.
    - Resistance issues: WSSA Group 22
    - Other:
        - Safer to the pumpkin crop for burndown treatment. This is mainly if paraguat is used as a directed treatment between rows. Unlike glyphosate, it does not translocate and will only damage pumpkin plant parts it contacts. Also no-till is not recommend in pumpkins, so paraquat will control the small annual weeds emerging in a stale seedbed.

- pelargonic acid (Scythe)
    - Registration status: Section 3 (Biopesticide)
    - Rate: 3-10% concentration

- PHI: n/a PRE
- REI: 12 hours
- RUP or GUP: GUP
- Human health concerns: Causes substantial but temporary eye injury.
- Environmental concerns: None outstanding on label.
- Resistance issues: WSSA Group “fatty acid”
- Other:
  - Do not apply by air.
  - Contact, burndown product.
  - Not important for conventional or organic growers. Neither pelargonic acid nor Scythe is on the OMRI list, so unlikely to be used by organic growers. There is some use by home vegetable gardeners.

- sethoxydim (Poast)
  - Registration status: Section 3 (RED scheduled for 1/2006)
  - Rate: 0.5-1.5 pts (POST) (3 pts formulation per A*Y)
  - PHI: 14 days
  - REI: 12 hours
  - RUP or GUP: GUP
  - Human health concerns: Causes substantial but temporary eye injury. Not likely to be carcinogenic to humans.
  - Environmental concerns: Toxic to aquatic organisms.
  - Resistance issues: WSSA Group 1
  - Other:
    - Annual grass control only.
    - Similar to clethodim, but weaker on small grains, crabgrass and sandbur.
    - 2nd choice for most producers.
    - Would an increased label rate make this product more useful against perennial grasses? If so, consider that application of a POST herbicide to vining pumpkins is difficult. Furthermore, this product label is unlikely to change until after the RED is completed.

- trifluralin (Treflan HFP, Treflan TR-10)
  - Registration status: Section 3 (TRED signed 8/2004)
  - Rate: Varies based on formulation
  - PHI: 30 days
  - REI: 12 hours
  - RUP or GUP: GUP
  - Human health concerns: Causes moderate eye irritation. Allergic skin reaction. Group C (possible human carcinogen).
  - Environmental concerns: Extremely toxic to freshwater, marine, and estuarine fish and aquatic invertebrates.
  - Resistance issues: WSSA Group 3
  - Other:
    - Do not apply by air.
    - Current labeling (incorporation, row-middle only, no contact) makes this herbicide less useful to pumpkin growers. Not used in processing pumpkins.
    - Illinois (J. Masiunas) comments regarding current labeling: Trifluralin can injure pumpkin, especially during cold, wet weather. I feel uncomfortable with trifluralin applied in the pumpkin planting row. Pumpkin tolerance to dinitroanalines (trifluralin & ethalfluralin) is due to placement differences, the

seed is placed and germinates below the herbicide band. Trifluralin must be incorporated because of volatility concerns and low water solubility. Incorporation makes it more difficult to maintain this placement tolerance. Ethalfluralin has similar volatility concerns but has greater water solubility than trifluralin, so ethalfluralin can be "incorporated" by rainfall or irrigation.

"Pipeline" Herbicide Products:

- acetic acid /vinegar [Ecoval Technologies]
    - Registration status: Unknown for Pumpkins. Biopesticide. Registered in 1997 (Post-FQPA). Marketed in non-crop areas and as preservative in animal feed. It is in IR-4 biopesticide database as a funded proposal from TN (tomato and snapbean).
    - Weed spectrum: Many annual broadleaf weeds and grasses. POST-directed application. Contact herbicide, works by desiccation, no translocation. Re-growth is a problem, especially for perennial weeds, repeat applications necessary for control.
    - Human health concerns: EPA says, "Applicators are required to use protective equipment to prevent contact with skin and eyes."
    - Environmental concerns: EPA says "There are no risks to the public or the environment when the active ingredient is used according to the label."
    - Resistance issues: WSSA Group "unknown"
    - Other:
        - Must be directed between rows of pumpkin. If it contacts the crop, plant injury will occur.
        - Would be useful to the organic market (OMRI-listed). For the organic market it must result from fermentation and distillation, not dilution of synthetic glacial acetic acid.
        - USDA research shows that a product must contain 20% acetic acid for consistent weed control.

- *Colletotrichum gloeosporioides f. sp malvae* (Mallet WP) [Encore Technologies]
    - Registration status: Pending (Biopesticide)
    - Weed spectrum (IR-4 comments): It is pathogenic to round-leaved mallow, small flowered mallow, common mallow, and velvetleaf.
    - Human health concerns:
    - Environmental concerns:
    - Resistance issues: Fungal organism
    - Other:
        - Very little information available besides IR-4 information from 2000-2001 and Federal Register notice from EPA.
        - Not currently on USDA National Organic Program Approved Materials List.
        - Might be useful for organic market (if approved) or mixed with a synthetic herbicide that is poor against velvetleaf (i.e. dimethenamid-P).

- dimethenamid-P (Outlook) [BASF]
    - Registration status: Pending (Reduced risk)
    - Weed spectrum (IR-4 comments): Annual grasses, broadleaf weeds, yellow nutsedge.
    - Human health concerns: Group C (possible human carcinogen).

- Environmental concerns:
- Resistance issues: WSSA Group 15 (single isomer of dimethenamid).
- Other:
  - Poor on velvetleaf, good on nightshade.
  - Want the product as a PRE, not as a directed spray.
  - Illinois (J. Masiunas) evaluations found good pumpkin tolerance to PRE applications. However, the manufacturer will not support registration on pumpkins.

- flufenacet (Define) [Bayer]
  - Registration status: Potential (Post-FQPA)
  - Weed spectrum (IR-4 comments): Soil applied for annual grasses and some broadleaf weeds.
  - Human health concerns: Formulation contains crystalline silica a Group B (probable carcinogen).
  - Environmental concerns: Can leach into ground water and can runoff, contaminating surface water.
  - Resistance issues: WSSA Group 15
  - Other:
    - Good on grasses, not on broadleaves (exceptions are carpetweed, common purslane and spotted spurge)
    - Would like to see this product pursued. However, it would not be much of an addition except where clomazone + ethalfluran does not control carpetweed and spurge.

- flumioxazin (Valor 50 WD) [Valent]
  - Registration status: Potential (Post-FQPA)
  - Weed spectrum: Low use rate pre-emergence broadleaf herbicide with contact activity and residual soil activity. Would provide control of pigweeds & nightshade
  - Human health concerns: Brief or minor eye and skin irritation. Anemia and other blood formation changes from high exposures. Not likely carcinogenic to humans.
  - Environmental concerns: Slight to moderate toxicity to aquatic species.
  - Resistance issues: WSSA Group 14
  - Other:
    - Good as PRE.
    - N-phenylphthalimide derivative.
    - Would like to see this product pursued. Has POST activity against important broadleaf weeds. Might have potential if adequate pumpkin tolerance.

- fomesafen (Reflex) [Syngenta]
  - Registration status: Potential
  - Weed spectrum: Broadleaf weeds [*Amaranthus* spp., nightshade, ragweed, common lambsquarters, etc.]
  - Human health concerns: Group C (possible human carcinogen).
  - Environmental concerns: Toxic to fish. Persists in the soil. Mobile in soil and will leach.
  - Resistance issues: WSSA Group 14
  - Other:

        - IR-4 project #09115 (http://ir4.rutgers.edu/Food_Use.cfm, accessed 4/14/05) shows that Tennessee requested registration of this product for use on pumpkin. Manufacturer placed a hold on this project.
        - Look into testing and registering this product. Unlikely candidate because POST treatment will cause too much injury. However, may be a PRE candidate either alone or with s-metolachlor (will control pigweeds and nightshade).

- imazamox (Raptor) [BASF]
    - Registration status: Potential (Post-FQPA. Reduced risk.)
    - Weed spectrum: Emerged broadleaf weeds and grass less than 3 inches tall
    - Human health concerns: Not likely to be carcinogenic to humans.
    - Environmental concerns:
    - Resistance issues: WSSA Group 2 (ALS-inhibitor like halosulfuron, so cross-resistance might be an issue)
    - Other:
        - Not in IR-4 pumpkin project list.
        - Has lower rotational restriction than Pursuit.
        - Want it as a PRE option for pumpkins. Good pumpkin tolerance when applied as a PRE, but weed control is better as a POST.
        - Injury too great when applied as a POST. Might have potential as a POST when combined with low rates of bentazon (Basagran) as a protectant. [see Supplemental label for lima, pea, or snap bean].

- lactofen (Cobra) [Valent]
    - Registration status: Potential
    - Weed spectrum: Broadleaf weeds.
    - Human health concerns: Corrosive, causing irreversible eye damage. Causes skin burns. Harmful if ingested, inhaled, or absorbed through the skin. Group C (possible human carcinogen)
    - Environmental concerns:
    - Resistance issues: WSSA Group 14
    - Other:
        - PRE application to direct-seeded pumpkin with a band of activated charcoal.
        - IR-4 project #05301 (http://ir4.Rutgers.edu/Food_Use.cfm, accessed 6/24/05) Oregon requested registration of this product for use on pumpkin. Manufacturer has placed a hold on this project.
        - Would activated charcoal be able to prevent injury after emergence, especially from volatilization?
        - Would oxyfluorfen (Goal) be a better choice for this use pattern?

- pyrithiobac-sodium (Staple) [DuPont & K-I Chemical]
    - Registration status: Potential
    - Weed spectrum (IR-4 comments): Controls a wide range of broadleaf weeds via pre- and post-emergence application.
    - Human health concerns: Causes skin and eye irritation. Group C (possible human carcinogen).
    - Environmental concerns: Highly toxic to nontarget plants. Avoid water contamination.
    - Resistance issues: WSSA Group 2
    - Other:

        - Probably do not need to pursue; it is another ALS inhibitor (resistance within *Amaranthus* is a concern). It does not add anything over halosulfuron.

- S-metolachlor (Dual Magnum) [Syngenta]
    - Registration status: Potential (Reduced Risk. TRED Signed 5/2002.)
    - Weed spectrum (IR-4 comments): Same spectrum as metolachlor (Dual). PPI/PRE.
    - Human health concerns: Causes skin, eye, and respiratory irritation. Group C (possible human carcinogen).
    - Environmental concerns: Slight to moderate toxicity to fish.
    - Resistance issues: WSSA Group 15
    - Other:
        - IR-4 request dropped. So no current study or registration likely.
        - Would be a very welcome addition! May be a PRE candidate with fomesafen (will control pigweeds and nightshade).

ACKNOWLEDGEMENTS

CONTRIBUTORS

Many thanks to the following individuals who contributed to this publication in a variety of ways.

- Mohammad Babadoost — University of Illinois, Dept. of Crop Sciences
- Dave & Carolyn Cattron — Alexander Farms, Inc. (Joliet, IL)
- John Coulter — Coulter Farms (Westville, IN)
- Brent Dallinger — Seneca Foods Corp. (Princeville, IL)
- Dan Disselkoen — County Line Growers (Grant Park, IL)
- Dan Egel — Purdue University, SW Purdue Agricultural Center
- Phil Foster — Huntington Orchards, Inc. (Huntington, IN)
- Rick Foster — Purdue University, Dept. of Entomology
- Leonard Frey — Frey Farms (Poseyville, IN)
- Randy Gaitcsh — Randy's Vegetables (Dundee, IL)
- Corey Gerber — Purdue University, Dept. of Agronomy
- Chris Gunter — Purdue University, SW Purdue Agricultural Center
- John Hilger — Hilger Farm Market (Ft. Wayne, IN)
- Lynnae Jess — Michigan State University, North Central IPM Center
- Lewis Jett — University of Missouri, Dept. of Horticulture
- Tom Laatsch — Nestle USA (Morton, IL)
- Frankie Lam — Purdue University, SW Purdue Agricultural Center
- John Masiunas — University of Illinois, Dept. of NRES
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- John Miller — Miller's Market, Inc. (Neponset, IL)
- Philip Nixon — University of Illinois, Dept. of NRES
- Maurice Ogutu — University of Illinois, Countryside Extension Center
- Charlie Orcutt — Private Consultant (Melvin, IL)
- Bruce Paulsrud* — University of Illinois, Dept. of Crop Sciences
- Bill Shoemaker — University of Illinois, St. Charles Hort. Res. Center
- Henry Taber — Iowa State University, Dept. of Horticulture
- Justin Talley — Frey Farms (Keenes, IL)
- Barbara VanTil — US EPA - Region 5, Pesticides Program Section
- Elizabeth Wahle — University of Illinois, Edwardsville Extension Center
- Alan Walters — S. Illinois University, Dept. of Plant, Soil and Gen. Ag.
- Bruce Waterman — Waterman's Farm Market (Indianapolis, IN)
- Rick Weinzierl — University of Illinois, Dept. of Crop Sciences
- Steve Weller — Purdue University, Dept. of Hort. & Landscape Arc.
- Bill Whiteside — Private consultant (Batavia, IL)

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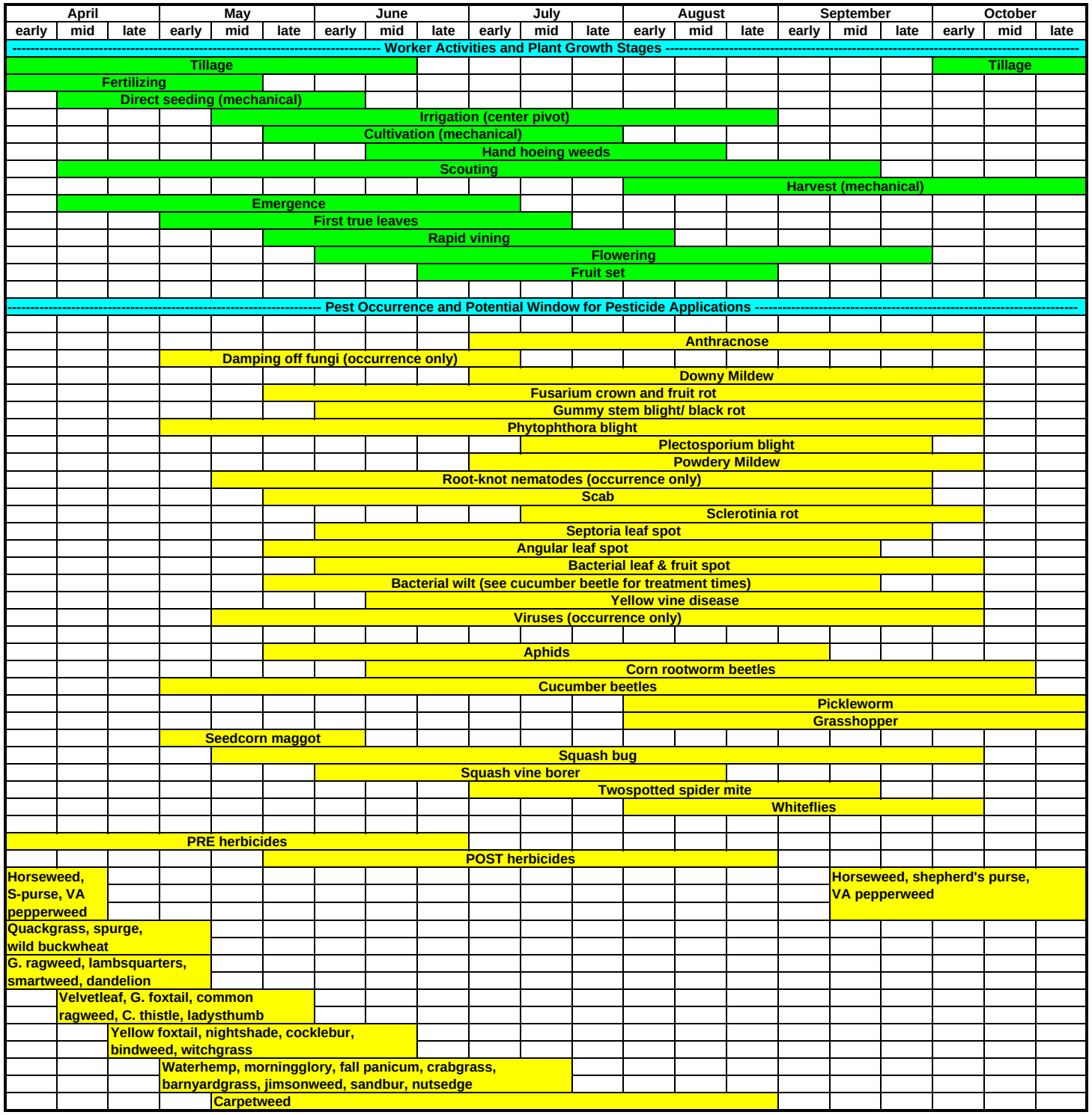
REFERENCES

- "2002 Census of Agriculture, Volume 1 Chapter 2: U.S. State Level Data (Table 29)." National Agriculture Statistics Service [on-line]. <www.nass.usda.gov/census/census02/volume1/us/index2.htm>. Accessed 3/6/05.
- Pest descriptions were taken primarily from: Babadoost, M., R. Weinzierl, and J. Masiunas. "Identifying and Managing Cucurbit Pests." Circular 1392. University of Illinois Extension, 2004.
- "Chemicals Evaluated for Carcinogenic Potential." U.S. Environmental Protection Agency [on-line]. <www.epa.gov/pesticides/carlist>. Received via email request 4/4/05.
- Egel, D., *et. al*. "Midwest Vegetable Production Guide for Commercial Growers 2005." Multi-state publication available in print from Iowa State University, Purdue University, University of Illinois, University of Minnesota and University of Missouri. Also available online <www.entm.purdue.edu/Entomology/ext/targets/ID/>.
- Fungicide Resistance Action Committee (FRAC). <www.frac.info>.
- Gerber, C., R. Foster, *et. al*. "Illinois, Indiana, Iowa and Missouri Pumpkin Crop Profile." (in press).
- Herbicide Resistance Action Committee (HRAC). <www.plantprotection.org/hrac>.
- Insecticide Resistance Action Committee (IRAC). <www.irac-online.org>.
- "New Pest Control Technologies." The IR-4 Project [on-line]. <www.ir4.rutgers.edu/newchem.cfm>. Accessed 3/6/05.
- "Specific Chemical Fact Sheets." U.S. Environmental Protection Agency [on-line]. <www.epa.gov/pesticides/factsheets/chemical_fs.htm>. Accessed 2/22/05 – 3/11/05.

Appendix 1a: Field Activity Timeline for Jack-o-Lantern Pumpkins

April			May			June			July			August			September			October		
early	mid	late	early	mid	late	early	mid	late	early	mid	late	early	mid	late	early	mid	late	early	mid	late
Worker Activities and Plant Growth Stages																				
Tillage																		Tillage		
Fertilizing																				
			Direct seeding (mechanical)																	
				Irrigation (center pivot or solid set)																
					Cultivation (mechanical)															
							Hand hoeing weeds													
				Scouting																
												Harvest (mechanical)								
												Harvest (hand picking)								
				Emergence																
					First true leaves															
							Rapid vining													
								Flowering												
									Fruit set											
Pest Occurrence and Potential Window for Pesticide Applications																				
									Anthracnose											
			Damping off fungi (occurrence only)																	
									Downy Mildew											
					Fusarium crown and fruit rot															
						Gummy stem blight/ black rot														
			Phytophthora blight																	
										Plectosporium blight										
									Powdery Mildew											
				Root-knot nematodes (occurrence only)																
					Scab															
										Sclerotinia rot										
						Septoria leaf spot														
					Angular leaf spot															
						Bacterial leaf & fruit spot														
					Bacterial wilt (see cucumber beetle for treatment times)															
							Yellow vine disease													
				Viruses (occurrence only)																
					Aphids															
									Corn rootworm beetles											
			Cucumber beetles																	
												Pickleworm								
												Grasshopper								
			Seedcorn maggot																	
				Squash bug																
						Squash vine borer														
									Twospotted spider mite											
												Whiteflies								
PRE herbicides																				
					POST herbicides															
Horseweed, S-purse, VA pepperweed																Horseweed, shepherd's purse, VA pepperweed				
Quackgrass, spurge, wild buckwheat																				
G. ragweed, lambsquarters, smartweed, dandelion																				
	Velvetleaf, G. foxtail, common ragweed, C. thistle, ladysthumb																			
		Yellow foxtail, nightshade, cocklebur, bindweed, witchgrass																		
			Waterhemp, morningglory, fall panicum, crabgrass, barnyardgrass, jimsonweed, sandbur, nutsedge																	
				Carpetweed																

Appendix 1b: Field Activity Timeline for Processing Pumpkins



Appendix 2: Pumpkin Varieties[1]

Size/Type	Names
Miniature	PMT[2]: Gold Dust.
	Not PMT: Apprentice, Baby Boo (white), Jack Be Little, Mini-Jack, Munchkin, Sweetie Pie, Wee-B-Little.
Small	PMT: Cannonball, Iron Man, Mystic Plus, Touch of Autumn.
	Not PMT: Baby Bear, Hybrid Pam, Neon, Orange Smoothie, Oz, Pik-a-Pie, Small Sugar, Spookie, Spooktacular.
Medium	PMT: Magician (homozygous for PM tolerance, also tolerant to ZYMV), Merlin.
	Not PMT: Gold Fever, Gold Standard, Jack of all Trades, New Rocket, Tom Fox, Wizard.
Large	PMT: Aladdin, Gladiator, Hercules, Magic Lantern.
	Not PMT: Appalachian, Autumn King, Big Rock, Dependable, Gold Gem, Gold Medal, Harvest Time, Howden Biggie, Trojan.
Very large	Atlantic Giant, Big Herc, Big Max, Big Moon, Prize Winner.
Speciality types	Buckskin, Fairytale, Jarradale, Rouge Vif D'Etampes (Cinderella).
Hull-less/naked seed	Snack Jack, Triple Treat (medium size, can also be used as a Halloween type).
Processing	Dickinson, Goldkeeper.

[1] Includes varieties that are available/most widely grown with good performance record.
[2] Powdery mildew tolerant.

Companies involved with pupkin breeding and/or seed sales.

Abbott & Cobb	www.acseed.com
Harris Moran	www.harrismoran.com
Hollar	www.hollarseeds.com
Johnny's Selected Seeds	www.johnnyseeds.com
Meyers Seed	www.giyp.com/brochure.asp?c=407864&cc=GIYP
Rispens	www.rispensseeds.com
Rupp Seeds	www.ruppseeds.com/divVegetable
Seedway	www.seedway.com
Seminis (Monsanto)	www.seminis.com/sales_regions/naca/naca_main.html
Siegers	www.siegers.com
Stokes	www.stokeseeds.com

Appendix 3: Product & Practice Efficacy Against Pumpkin Diseases

			Disease																				
			Anthracnose	Damping-off fungi	Downy mildew	Fusarium crown and fruit rot	Black rot	Phytophthora blight	Plectosporium blight	Powdery mildew	Root-knot nematodes	Scab	Sclerotinia rot	Septoria leaf spot	Angular leaf spot	Bacterial leaf & fruit spot	Bacterial wilt	Yellow vine disease	Cucumber mosaic virus (CMV)	Papaya ringspot virus, type w (PRSV-W)	Squash mosaic virus (SqMV)	Watermelon mosaic virus (WMV)	Zucchini yellow mosaic virus (ZYMV)
Pest Management Tools:	**Pest ranking (IL, IN, IA & MO)--->**		**2B**	**1C**	**1A**	**2A**	**2B**	**1A**	**1C**	**1C**	**3A**	**3C**	**3A**	**2C**	**2A**	**1A**	**3B**	**2B**			**1A**		
Registered materials	**Active Ingredient(s)**	**Group**																					
Amistar, Heritage, Quadris F	azoxystrobin	11	G	F	G	N	G	N	G	G	N	?	?	?	N	N	N	N	No effect	No effect	No effect	No effect	No effect
Quadris Opti	azoxystrobin + chlorothalonil	11,M5	G	?	G	N	G	N	G	G	N	?	?	?	N	N	N	N					
Sonata	Bacillus pumilis QST 2808	?	P?	?	P	?	P	?	P	P	?	?	?	?	?	?	?	?					
Kodiak	Bacillus subtillis GBO3	?	?	P?	?	?	?	?	?	?	?	?	?	?	?	?	?	?					
Serenade AS	Bacillus subtillis QST 713	?	P?	?	P	?	P	?	P	P	?	?	?	?	?	?	?	?					
Pristine	boscalid + pyraclostrobin	7,11	G	?	G	?	G	P	G	G	N	?	?	?	N	N	N	N					
Captan	captan	M4	N	G	N	N	N	N	N	N	N	N	N	N	N	N	N	N					
Bravo, Echo, Equus	chlorothalonil	M5	G	?	F	N	G	?	?	P	N	G	?	?	N	N	N	N					
Ridomil Gold Bravo	chlorothalonil + mefenoxam	M5,4	?	G	G	?	?	G	?	N	N	?	?	?	N	N	N	N					
Tenn-Cop, Champ, Kocide, KOP	copper	M1	P	N	F	?	P	P	?	P	N	?	?	?	F	F	?	?					
Cuprofix Disperss	copper sulfate	M1,M2	P	N	P	?	P	F	?	P	N	?	?	?	F	F	?	?					
Curzate 60DF	cymoxanil	27	N	?	G	N	?	F	?	N	N	?	?	?	?	?	?	?					
Tanos	cymoxanil + famoxadone	27,11	F	F	G	?	?	G	?	?	N	?	?	?	?	?	?	?					
Acrobat	dimethomorph	15	?	?	G	N	?	G	?	?	N	?	?	?	P	P	?	?					
Reason 500 SC	fenamidone	11	?	?	G	?	?	?	?	?	?	?	?	?	?	?	?	?					
Maxim 4FS	fludioxonil	12	?	G	?	?	?	?	?	?	N	?	?	?	N	N	N	N					
Aliette WDG, Agriphos, Fosphite, Phostrol, Prophyt	fosetyl-AL, phosphorous acid, potassium phosphite	33	?	P	F	?	?	P	?	?	N	?	?	?	?	?	?	?					
Maneb 75 DF, Manex	maneb	M3	F	?	F	?	G	F	?	?	N	?	?	?	?	?	?	?					
Apron XL LS, Ridomil, Ultra Flourish	mefenoxam	4	?	G	G	?	?	G	?	?	N	?	?	?	N	N	N	N					
Nova 40W	myclobutanil	3	?	?	?	?	?	?	?	G	N	?	?	?	N	N	N	N					
Trilogy	neem oil	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?					
Vydate L (insecticide/nematicide)	oxamyl	1A**	N	N	N	N	N	N	N	N	F	N	N	N	N	N	N	N					
Armicarb, Eco-Mate Armicarb "O"	potassium bicarbonate	?	?	?	?	?	?	?	?	F	N	?	?	?	N	N	N	N					
Previcur Flex	propamocarb hydrocloride	28	?	?	G	?	?	?	?	?	N	?	?	?	N	N	N	N					
Cabrio EG	pyraclostrobin	11	G	?	G	?	G	P	G	G	N	?	?	?	N	N	N	N					
Topsin 70 WSB	thiophanate-methyl	1	G	?	N	P	F	N	?	G	N	?	?	?	N	N	N	N					
42-S Thiram	thiram	M3	?	F	?	?	?	?	?	?	N	?	?	?	N	N	N	N					
Flint	trifloxystrobin	11	?	?	G	?	?	?	?	G	N	?	?	?	N	N	N	N					
Procure 50 WS	triflumizole	3	?	?	?	?	?	?	?	G	N	?	?	?	N	N	N	N					
Pending & Potential Materials	**Active Ingredient(s)**	**Group**																					
Actigard, Blockade	acibenzolar	P1	?	?	?	?	?	?	N	N	N	?	?	?	?	?	?	?	No effect	No effect	No effect	No effect	No effect
AQ 10	*Ampelomyces quisqualis* isolate M-10	?								?													
Taegro	*Bacillus subtilis*	?																					
KIF-230	benthiavalicarb	U1			?			?															
Honor	boscalid	7								?													
Ranman 400 SC	cyazofamid	21	?	?	G	?	?	F	?	?	N	?	?	?	N	N	N	N					
NF-149, Pancho	cyflufenamid	?								?													
Switch	cyprodinil + fludioxonil	9,12			P?			?															
Guardian	ethaboxam	U5			?			?															
AuxiGro	glutamic acid	?																					
Vortex	ipconazole	3																					
Sovran, Cygnus	kresoxim-methyl	11					?			?				?									
Frupica, Cockpit, TD-2448	mepanipyrim	9																					
Milsana Bioprotectant	milsana bioprotectant	?								?													
Arabesque	*Muscodor albus*	?																					
Strain 251, Bio Act, Melo-Con WG	*Paecilomyces lilacinus*	?									?												
MFT 753	penthiopyrad	?								?													
Actinovate, Actino-Iron	*Streptomyces lydicus* WYEC 108	?		?																			
(trade name unknown)	SYP-L190 (flumorth?)	?			?			?															
(trade name unknown)	SYP-Z071 (enestroburin?)	11?	?		?		?	?		?		?											
Folicur, Elite, Raxil	tebuconazole	3	?							G													
(trade name unknown)	V-10118 (by Valent)	?								?													
Cultural/Non-chemical:																							
Crop rotation			2	?	?	>4	3	>3	3-4	2	>6	3-4	?	2	2	2	?	?	1	1	1	1	1
Soil drainage			2	3	1	3	2	3	2	1	1	2	3	1	2	2	1	1	1	1	1	1	1
Tillage			3	1	1	2	2	1	2	2	2	2	2	3	3	2	1	1	1	1	1	1	1
Variety selection/ host resistance			1	1	1	1	1	1	1	3	1?	1	1	1	1	1	1	1	1	1	1	1	1
Certified disease-free seed			3	1	1	2	2	1	1	1	1	2	1	1?	3	3	1	1	1	1	3	1	1
Planting date			1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	2
Irrigation/moisture			3	2	3	3	3	3	3	1	1	2	3	2	3	3	1	1	1	1	1	1	1
Insect vector control			1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3
Weed and vollunteer control			1	1	1	1	1	2	1	1	2	1	2	1	2	2	1	1	2	1	1	1	1

Pest rankings: Occurrence (1 = common, 2 = intermediate, 3 = uncommon); Ability to control (A = difficult, B = intermediate, C = easy).
Pesticide ratings: G = good; F = fair; P = poor; N = None/not labeled; ? = more research needed; NU = not used; * = used but not necessarily a stand alone management tool.
Rotation: number indicates the number of years that the field should be planted to a non-cucurbit crop.
Cultural practice ratings: 1 = limited effect, 2 = moderate importance, 3 = important tool.
Group: Fungicide Resistance Action Committee classification by fungicide site of action. (** Oxamyl belongs to IRAC Group 1A)

Appendix 4: Product & Practice Efficacy Against Pumpkin Insects & Insect Relatives

			Insects and Insect Relatives									
			Aphids **	Corn rootworm beetles	Cucumber beetles	Grasshopper	Pickleworm	Seedcorn maggot	Squash bug	Squash vine borer	Twospotted spider mite	Whiteflies
Pest Management Tools:	**Pest ranking (IL, IN, IA & MO)--->**		**1C**	**1C**	**1C**	**3B**	**3B**	**2B**	**1C**	**1A**	**3B**	**3B**
Registered materials	**Active Ingredient(s)**	**Group**										
Agri-Mek 0.15EC	abamectin	6	N	N-P	N-P	N	N	N	N	N	G	N
Neemix	azadirachtin	26	P-F	P	P	N?	N?	N	N-P	N-P	P	F
Deliver, Javelin, Condor, Lepinox, Crymax	*B.t. kurstaki*	11B2	N	N	N	N	F	N	N	P-F	N	N
Acramite 50WS	bifenazate	25	N	N	N	N	N	N	N	N	G	N
Capture 2 EC	bifenthrin	3	G	G	G	G	G	N	G	G	F	F-G
Sevin 80 WSP, 80S, XLR+	carbaryl	1A	N-P	G	G	G	F	N	P-F	G	N	N
Furadan 4F	carbofuran	1A	N-P	N	G	N	N	F-G	(F)	N	N	N
Lorsban 30, 50-SL	chlorpyriphos	1B	N	N	N	N	N	G	N	N	N	N
Trigard	cyromazine	17	N?	N?	N?	N	N	N	N?	N	N	N
Kelthane 35	dicofol	20	N	N	N	N	N	N	N	N	F	N
Endosulfan, Phaser 3EC, Thiodan	endosulfan	2A	F-G	P-F	F-G	F	F	N	F	F	P	F
Asana XL	esfenvalerate	3	P-F	G	G	G	G	N	F	G	N	F
Danitol 2.4 EC	fenpropathrin	3	F	G	G	G	G	N	F	G	F	F
Admire 2F	imadacloprid	4A	G	G	G	N	N	G*?	(F)	N	N	(N-P)
Surround WP	kaolin	?	P?	P	P	P	P	N	N-P	N-P	N	N-P
Malathion 57 EC	malathion	1B	G	F	F	F	F	N	P	F	N	P-F
Intrepid 2F	methoxyfenozide	18	N	N	N	N	F	N	N	N	N	N
Trilogy	neem oil	?	P-F	N-P	N-P	N?	N?	N	N-P	N	N	N
Vydate L	oxamyl	1A	F	N-P	N-P	N	N	N	?	?	P	N
MSR Spray Concentrate	oxydemeton-methyl	1B	G	P	P	N	N	N	P	P	P	P-F
Ambush 25W, Pounce	permethrin	3	G	G	G	G	G	N	F	G	N	N
M-Pede	potassium salts	?	G	P	P	N	N	N	P-F	N	P-F	G
Fulfill	pymetrozine	9B	G	N-P	N-P	N	N	N	N	N	N	G
Knack	pyriproxyfen	7C	N-P	N-P	N-P	N	N	N	N	N	N	G
could not find agricultural label	rotenone	21	P	F-G	F-G	P	P	N	P	F	N	N
Entrust, SpinTor, Success	spinosad	5	N-P	F	F	P	F	N	N-P	F	N	N-P
Platinum	thiamethoxam	4A	G	F-G	F-G	N	N	G	(F)	N	N	(N-P)
Pending & Potential Materials	**Active Ingredient(s)**	**Group**										
DBI-3204	bistrifluron	15?										
Matric	chromafenozide	18										
Poncho, Clutch	clothianidin	4A	?	?	?			?	?	?	N-P	?
Baythroid, Renounce 20 WP	cyfluthrin	3	P	G	G			N	F	G	N-P	P-F
Stackle	dinotefuran	4A										
Proclaim, Strategy, Denim	emamectin benzoate	6										
Trebon	etofenprox	3										
Zeal	etoxazole	10B	N	N	N			N	N	N	G	N
Turbine 50 WG	flonicamid	9C										
(trade name unknown)	flufenzin	?										
Avaunt, Steward	indoxacarb	22	P	?	?			?	?	?	N-P	N-P
Taerain	*Metarhizium anisopliae*	?										
Nexter 75 WP, Sanmite	pyridaben	21										
Oberon 2 SC, BSN 2060	spiromesifen	23										
Calypso 4 Flowable, Alanto, Bariard	thiacloprid	4A	F-G	?	?			?	?	?	N	F-G
Evisect	thiocyclam	?										
Hachihachi	tolfenpyrad	21										
Fury, Mustang, Mustang Maxx	zeta-cypermethrin	3	P	G	G			N	F	G	N-P	P-F
Cultural/Non-chemical:												
Crop rotation			1	1	2	1	1	2?	2	1	1	1
Irrigation			1	1	1	2	1	1	1	1	2	1
Planting date			3	1	1	1	1	2	1	2	1	1
Variety selection/host resistance			1	1	1	1	1	1	1	1	1	1
Baited traps for monitoring			?	1	2	1	3	1	2	3	1	1
Mowing/disking cover crops			1	1	1	1	1	3	1	1	1	1
Sticky traps			?	1	?	1	?	1	1	?	2	2
Certified pest-free plants			1	1	1	1	1	1	1	1	1	3
Weed control			3	1	1	2	1	1	1	1	2	1
Sanitation			1	1	1	1	1	1	2	1	1	1
Tillage			1	1	1	2	1	2?	2	1	1	1

Pest rankings: Occurrence (1 = common, 2 = intermediate, 3 = uncommon); Ability to control (A = difficult, B = intermediate, C = easy).
Pesticide ratings: G = good; F = fair; P = poor; N = None/not labeled; ? = more research needed; NU = not used; ( ) = not right timing
* = used but not necessarily a stand alone management tool
Cultural practice ratings: 1 = limited effect, 2 = moderate importance, 3 = important tool
Group: Insecticide Resistance Action Committee classification by insecticide site of action.
** Does not imply virus control

Appendix 5: Product & Practice Efficacy Against Pumpkin Weeds

			Broadleaf Weeds																						Grass Weeds												Other
			Annuals																			Perennials			Annuals									Perennials				
			Carpetweed	Common cocklebur	Common lambsquarters	Common purslane	Eastern black nightshade	Horseweed (Marestail)	Morningglory spp.	Jimsonweed	Ladysthumb, PA smartweed	Pigweeds/waterhemp	Prickly sida	Prostrate spurge	Common ragweed	Giant ragweed	Shepherd's purse	Smallflower galinsoga	Velveteleaf	Virginia pepperweed	Wild buckwheat	Canada thistle	Dandelion	Field bindweed	Barnyardgrass	Crabgrass	Downy brome	Fall panicum	Foxtails	Goosegrass	Sandbur	Shattercane	Witchgrass	Bermudagrass	Johnsongrass	Quackgrass	Sorghum almum	Yellow nutsedge
Pest Management Tools:	**Pest ranking (IL, IN, IA & MO)--->**		1C	1C	1C	1C	1A	1A	1A	1C	2C	1A	2B	1C	1B	1A	2C	1A	1C	2A	1A	1A	1A	1A	1C	1B	1C	1C	1C	1C	2B	1C	2C	3A	1A	2A	2C	1A
Registered materials	**Active Ingredient(s)**	**Group**																																			
Prefar 4E	bensulide	8	N	N	F	F	N	N	N	N	N	F	N	N	N	N	N	N	N	N	N	N	N	N	G	G	F	G	G	G	P	F	F	N	N	N	N	N
Aim	carfentrazone-ethyl	14	F	F	G	N	G	N	G	N	F	F-G	F	N	F	N	F	N	G	P	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Arrow 2EC, Prism, Select	clethodim	1	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	G	G	G	G	G	G	G	G	G	P	P	G	P	N
Command 3 ME	clomazone	13	N	F	G	G	P	P	P	F	F-G	P	G	P	F	P	N	P	G	N	N	N	N	N	G	G	N	G	F-G	G	F	N	N	N	N	N	N	N
Strategy	clomazone + ethalfluralin	13,3	G	F	G	F	P	P	P	F	F	F	G	P	F	P	N	P	G	N	N	N	N	N	G	G	N	G	G	G	N	G	N	N	N	N	N	N
Matran	clove oil	?	F	F	G	G	G	F	G	F	G	G	F	F	F	F	G	G	G	G	P	N	N	N	F	F	F	F	F	F	F	F	F	N	N	N	N	N
Curbit 3 EC	ethalfluralin	3	G	N	F	G	F	N	N	N	F-G	G	N	N	N	N	N	F	N	N	N	N	N	N	G	G	N	G	G	G	N	G	N	N	N	N	N	N
Roundup, Credit, many	glyphosate	9	G	G	G	G	G	G	G	G	G	G	F	F	G	G	G	G	G	G	F	P-F	F	P	G	G	G	G	G	G	G	G	G	P	P	P-F	F	F
Sandea	halosulfuron	2	F	G	P	F	N	N	P	P	F-G	F-G	N	G	G	F	G	G	G	F	P	P	P	P	P	N	N	N	N	N	N	N	N	N	N	N	N	G
Boa, Gramoxone Extra	paraquat	22	G	G	G	G	G	G	F	G	G	G	G	F	G	F	G	F-G	G	G	F	P	P	P	G	G	G	G	G	G	G	G	G	P	P	P	P	F
Scythe	pelargonic acid	?	G	G	G	G	G	F-G	G	G	G	G	G	F	G	G	G	G	G	G	F	P	P	P	G	G	G	G	G	G	G	G	G	P	P	P	P	P
Poast	sethoxydim	1	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	G	F-G	G	G	G	G	F	G	G	P	P	P	P-F	N
Treflan HFP	trifluralin	3	G	N	G	G	P	N	N	N	N	G	N	N	N	N	N	N	P	N	N	N	N	N	G	G	G	G	G	G	G	G	F	N	N	N	N	N
Pending & Potential Materials	**Active Ingredient(s)**	**Group**																																			
several	acetic acid (vinegar)	?	F	F	G	G	G	F	G	F-G	G	G	F	F	G	F-G	G	G	G	G	P	F	P	N	F	F	F	F	F	F	F	F	F	P	N	N	P	N
Mallet WP	*Colletotrichum gloeosporioides* f. sp *malvae*	?	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	F?	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Outlook	dimethenamid-P	15	G	N	F	G	G	N	N	P	P	G	N	N	P	P	F	G	P	F	N	N	N	N	G	G	F	G	G	G	P	P	G	N	N	N	N	P
Define	flufenacet	15	G	N	P-F	G	P-F	N	N	N	N	P	P-F	G	P-F	N	N	N	N	N	N	N	N	N	G	G	N	G	G	G	F	N	G	N	N	N	N	F
Valor 50 WD	flumioxazin	14	G	N	G	G	G	G	F	F	F	G	G	N	G	N	G	N	F-G	N	N	N	G	N	P	P	N	P	P	P	N	N	N	N	N	N	N	N
Reflex	fomesafen	14	F	F	N	N	F-G	N	G	G	F-G	G	N	P	F-G	F-G	N	N	P	N	F	P	F	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Raptor (POST)	imazamox	2	N	P	F	F	G	N	F	G	F-G	G	P	F	F	G	G	N	G	N	N	N	N	N	G	F	G	G	G	N	F	G	N	N	N	N	N	N
Cobra	lactofen	14	N	G	P	N	G	N	F-G	G	N	G	P	P	G	G	N	F	F	N	P	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Staple	pyrithiobac-sodium	2	N	G	G	P	F	N	G	G	G	F	P	N	N	N	N	N	G	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	P-F
Dual Magnum	S-metolachlor	15	G	N	F	G	G	N	N	P	P	G	N	N	P	P	N	G	N	N	N	N	N	N	G	G	N	G	G	G	P	N	G	N	N	N	N	G
Cultural/Non-chemical:																																					
Field selection			1	2	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	2	3	2	3	1	1	1	1	1	1	2	1	1	3	3	3	2	3
Crop rotation			2	1	1	2	1	1	1	1	1	1	1	1	1	1	2	2	1	2	2	2	2	2	1	2	1	1	1	1	1	1	1	2	2	2	2	2
Proper fertility (canopy management)			2	1	1	2	1	1	1	2	1	2	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
Planting date			1	2	2	2	1	1	2	1	1	1	2	1	1	1	2	1	1	2	1	1	1	1	1	2	2	2	1	1	1	2	1	1	1	1	1	1
Strip-till/cover crop			1	1	2	2	1	2	1	1	2	2	1	2	1	1	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Plastic mulch			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Tillage/cultivation			2	2	2	2	2	2	1	2	2	2	1	2	1	1	2	2	2	2	2	1	2	1	2	1	1	1	2	2	2	2	2	1	1	1	1	1
Rotary-hoeing			1	2	2	1	1	1	1	1	2	2	2	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	2	2	1	1	2	1	1	1	1	1
Hand-weeding (hoeing)			2	2	2	1	2	1	1	2	2	2	1	2	1	1	2	2	2	1	1	1	1	1	2	2	1	1	2	2	2	2	2	1	1	1	1	1
Flaming			1	1	2	1	1	2	1	2	2	2	1	1	2	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Pest rankings: Occurrence (1 = common, 2 = intermediate, 3 = uncommon); Ability to control (A = difficult, B = intermediate, C = easy).
Pesticide ratings: G = good; F = fair; P = poor; N = None/not labeled; ? = more research needed; NU = not used; * = used but not necessarily a stand alone management tool.
Cultural practice ratings: 1 = limited effect, 2 = moderate importance, 3 = important tool.
Group: Weed Science Society of America classification by herbicide site of action.

Appendix 6: Insecticide and Miticide Toxicity Towards Selected Beneficials

Pest Management Tools:		Beneficials								
		Aphid midges	Bacillus popillae	Bees	Beneficial mites	Big-eyed bug	Beneficial Nematodes	Green lacewings	Ladybird beetles	Parasites
Registered materials	**Active Ingredient(s)**									
Agri-Mek 0.15EC	abamectin	S	O	?	M	S	O	S	S	S
Neemix	azadirachtin	S	O	S	?	?	O	S-M	S	S
Deliver, Javelin, Condor, Lepinox, Crymax	*B.t. kurstaki*	O	O	O	O	O	O	O	O	O
Acramite 50WS	bifenazate	S	O	?	S	S	O	O-S	S	S
Capture 2 EC	bifenthrin	H	O	H	H	H	O	H	H	H
Sevin 80 WSP, 80S, XLR+	carbaryl	H	O	H (S*)	H	H	O	H	H	H
Furadan 4F	carbofuran	O	O	O	O	O	S-M	O	O	O
Trigard	cyromazine	?	O	?	?	?	O	?	?	?
Kelthane 35	dicofol	?	O	?	H	S	O	?	S	S
Endosulfan, Phaser 3EC, Thiodan	endosulfan	M	O	M	M	M	O	M	M	M
Asana XL	esfenvalerate	H	O	H	H	H	O	H	H	H
Danitol 2.4 EC	fenpropathrin	H	O	H	M	H	O	H	H	H
Admire 2F	imadacloprid	S	O	O	O	O	?	O	O	O
Surround WP	kaolin	S	O	S	S-M	S	O	S	S	S
Malathion 57 EC	malathion	M	O	M	M	M	O	M	M	M
Intrepid 2F	methoxyfenozide	S	O	O	O	O	O	O	O	O
Trilogy	neem oil	S	O	O	?	?	O	?	?	S
Vydate L	oxamyl	H	O	H	H	H	O	H	H	H
MSR Spray Concentrate	oxydemeton-methyl	H	O	M	M	M	O	M	M	M
Ambush 25W, Pounce	permethrin	H	O	H	H	H	O	H	H	H
M-Pede	potassium salts	S	O	S	S	S	O	S	S	S
Fulfill	pymetrozine	?	O	?	?	?	O	?	?	?
Knack	pyriproxyfen	?	O	?	?	?	O	?	?	?
could not find agricultural label	rotenone	H	O	H	H	M	O	M	H	M
Entrust, SpinTor, Success	spinosad	S	O	M	S	?	O	?	S	S
Platinum	thiamethoxam	S	O	O	O	O	?	O	O	O
Pending & Potential Materials	**Active Ingredient(s)**									
DBI-3204	bistrifluron	No specific data; consider as similar to other registered products in same chemical class.								
Matric	chromafenozide									
Poncho, Clutch	clothianidin									
Baythroid, Renounce 20 WP	cyfluthrin									
Stackle	dinotefuran									
Proclaim, Strategy, Denim	emamectin benzoate									
Trebon	etofenprox									
Zeal	etoxazole									
Turbine 50 WG	flonicamid									
(trade name unknown)	flufenzin									
Avaunt, Steward	indoxacarb									
Taerain	*Metarhizium anisopliae*									
Nexter 75 WP, Sanmite	pyridaben									
Oberon 2 SC, BSN 2060	spiromesifen									
Calypso 4 Flowable, Alanto, Bariard	thiacloprid									
Evisect	thiocyclam									
Hachihachi	tolfenpyrad									
Fury, Mustang, Mustang Maxx	zeta-cypermethrin									

Toxicity scale: S = slightly toxic; M = moderately toxic; H = highly toxic; O = nontoxic; ? = no data available

* XLR+ formulation is softer on bees than the other formulations of Sevin.