

Leek
Pest Management Strategic Plan

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Executive Summary

Top Priorities of Leek Production in New Jersey

Onion maggot control

Effective management of onion maggot is the top priority of leek growers in New Jersey, at least in the East Vineland area where approximately 95% of the state's leek crop is grown. Onion maggot is difficult to control with the currently registered insecticides when several other host crops—including dry bulb onions, green onions, shallots and garlic—are grown in close proximity. Isolation from other host crops by distances of greater than 0.5 mile is the best alternative control, which benefits leek growers in the rest of the state, but is impractical in the East Vineland area.

The currently registered insecticide, diazinon, provides moderate control of the larval (maggot) stage, but ineffectively controls onion maggot populations that have possible organophosphate resistance. Repeated spraying of the pyrethroid zeta-cypermethrin is required for the adult flies, but even so, control is moderate. If a spray application for the adults is missed due to inclement weather or other factors, it is very difficult for growers to regain control of the onion maggot population. Other registered materials for the maggot adult (flies) are even less effective.

Weed control

Effective weed control in leeks relies on sethoxydim and clethodim for grasses and DCPA for control of some broadleaves as well as some grasses. There isn't a registered herbicide that will control a broad spectrum of broadleaf weeds, especially the weed species unaffected by DCPA, nor is there a registered herbicide that will control perennial weeds, annual sedges, and winter annuals. Post-emergent broadleaf weed control relies heavily on cultivation with a tractor and hand weeding, thus adding to the grower's cost of production.

Priorities/Needs

Regulatory

- **Critical Need:** Register clothianidin (Poncho 600) as a seed treatment for the control of onion maggot larvae.
- **Critical Need:** Expand labels of other insecticides that have demonstrated effective onion maggot fly control (for example, cyromazine, which is labeled for use on leeks, but does not include onion maggot on the label).
- **Critical Need:** Expand the label for S-metolachlor (Dual) to include leeks, providing another broadleaf material that will complement the use of DCPA (Dacthal).
- Retain the registration of chlorothalonil on leeks for disease control, as there is no other replacement for it in the rotation of fungicidal modes of action.
- Expand labels of pesticides that are registered for related crops, such as dry bulb onions and green onions, to include leeks.

Research

- Request that IR-4 continue to evaluate new pesticides for leeks.

- Develop a bait for onion maggot fly in leeks and related crops.

Education

- Expand the list of fungicides in the 2010 Commercial Vegetable Production Recommendations for New Jersey to include all registered fungicides with good activity on purple blotch and downy mildew.
- Expand the disease control section for leek production in the 2010 Commercial Vegetable Production Recommendations for New Jersey to include damping-off controls and disease control in seed beds and greenhouse trays.
- For better timing of fungicide applications, notify leek growers via the Plant and Pest Advisory Newsletter when weather conditions favor disease onset.

Pest Management Strategic Plan Process

The Leek Crop Profile for New Jersey provided much of the information included in this summary. The Profile was compiled from surveys of New Jersey growers, field observations, and interviews with extension agents and extension specialists on leek production practices and pest management.

In an attempt to be more inclusive of the region's leek pest problems, with the assistance of Sandra Menasha (Cornell horticultural extension educator, Suffolk County, NY), we sent additional surveys to leek growers on Long Island, New York so their information could be included in this PMSP.

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* Reviewed the draft Leek PMSP either in whole or in part.

Background

Production Facts

- **State rank:** New Jersey ranks 2nd nationally in leek production, with approximately 250 acres; New York growers have approximately 30 acres
- **Typical yields:** 800 to 1000 boxes per acre; good yield up to 1500 boxes per acre
- **Annual production costs:** \$2500 to \$3000/acre
- **Percent of crop for processing and fresh market:** 100% fresh market

Production Regions

Approximately 95% of the leeks in the state are grown in southern New Jersey, in Gloucester, Cumberland, and Atlantic Counties. The remaining 5% are grown in central and northern New Jersey in small plantings of less than one acre, usually on heavy Piedmont soils. In southern New Jersey and on Long Island, leeks are grown on light coastal plain soils, loamy sands to sandy loams with very low organic matter. Winter temperatures are more moderate in the south than in central and northern New Jersey and the growing season in the southern end of the state is about two weeks longer.

Cultural Practices

Field establishment and horticultural practices

Annual planted acreage depends on the market and the availability of fields for rotation. Most growers have two plantings per year with the first planted in late winter/early spring (late February and March) and harvested in early- to mid-summer and a later planting in July, which may be harvested in November or overwinter and be harvested in early spring of the next year. A few growers have four plantings per year, with additional plantings made in late spring and early summer



Growers typically grow their own spring transplants, but a few purchase southern transplants for the early spring planting. All growers use their own transplants for later seedings. Seedbeds are occasionally established to supplement greenhouse-grown transplants. Seeds are planted in seedbeds or in greenhouses 12 to 16 weeks

prior to transplanting. Within-row spacing of transplants varies from 3 to 4 inches. Growers having small plantings of leeks may direct seed in the field for the first planting.

In the field, the transplants are set in raised flat beds with one to three and sometimes four rows per bed. Row spacing depends on the width of the bed and the number of rows growers choose to have. Typical beds have 3 rows with 17-inch row spacing. As the plants grow, the field is cultivated, throwing dirt onto the leek stems. This results in whiter lower stem and bulb portions of the plant. By harvest, the plants appear to be growing on ridges atop the bed. Per-acre plant populations vary, but may be as much as 40,000 to 45,000. The use of overhead irrigation is the norm.



Leeks are machine harvested by undercutting the bulb with a one-row potato harvester and then are sorted into bunches by hand.

Recommended varieties for New Jersey and the mid-Atlantic area include Arkansas, Carina, Leafall, Leekool, Leekwik, Otina, and Winora. The principal variety grown is Arkansas, which is a good, non-bulbing, winter-hardy variety. Of farmers surveyed, all planted Arkansas; Tadorna and Leekool were also grown. Varietal selection is mostly for winter hardiness and color. Blue-green leeks are preferred over green leeks.

Soil fertility

Fertility practices vary by farmer and local soil conditions. Some of the fertilizer usage is probably traditional, but at least one grower uses soil tests to determine phosphorus and potassium recommendations and then sidedresses with liquid N when other crops are receiving nitrogen sidedressing. Soil-applied rates of fertilizer between plantings are nitrogen (120–200 lbs. per acre); phosphorus (60–100 lbs. per acre); and potassium (100–120 lbs./acre). These amounts approximate Rutgers University recommendations for fertilizer usage on leeks. Growers may apply a total of 1800 to 2000 lbs. of fertilizer per acre with 2 to 4 sidedressings during the growing season.

Marketing and cost of production

All leeks are packed in crates or boxes and sold for the fresh market to either supermarkets or farm markets. Each container holds several bunches. There are usually three to four leeks per bunch.

Leek is an expensive crop to grow. Hand labor is required for all stages of production: transplanting, weeding at least once per planting, harvesting, washing off plants, and packing. The break-even price for 2008 was \$8–\$11 per crate (and the cost of each empty crate was \$2). In the fall of 2007 a crate of leeks sold for as little as \$5.50.

Critical Pest Information

Where leek plantings are small and widely separated from other related crops, weeds are the primary pest (either grasses or broadleaves, depending on the farm). The East Vineland area of southern New Jersey, however, contains relatively large acreages of leeks and other *Allium* crops, dry bulb onions, green onions, shallots, and garlic, all grown in close proximity. Under these conditions, onion maggot and onion thrips become the dominant and most important pests, closely followed by weeds. The same pattern seems to hold for the importance of disease pests with the growers in northern New Jersey and New York experiencing fewer problems with disease pests than growers in southern New Jersey. Responses from the New York growers reflected pest conditions that are similar to those in northern New Jersey.

Insects

The primary pests of leeks in New Jersey are similar to the pests of related crops (dry-bulb onions, green onions, shallots, and garlic). These pests include onion maggot and onion thrips. Minor pests include European corn borer, fall armyworm, and other caterpillars.

Onion maggot is the most serious insect pest for leeks grown in the East Vineland area of southern New Jersey, which includes portions of Cumberland and Atlantic counties. It is well established in onion production areas and local populations appear to have developed some insecticide resistance. The close proximity of leek to fields of related crops eliminates crop rotation as a useful tactic to reduce the onion maggot population. Leek growers in central and northern New Jersey and New York are more isolated and have smaller plantings, which reduces the concerns about onion maggot.

Onion thrips are also a difficult pest to manage. Their secretive habit of crawling under the leaf sheaths shelters them from direct contact with insecticides. Leeks, having a thicker leaf cuticle, are not as susceptible to feeding injury by thrips as are onions.

Both pests are controlled by routine insecticide applications, but in both cases, if an application is missed, it is difficult for the growers to avoid increased crop damage.

Weeds

There is no single weed species that interferes with leek production; however, there are broadleaf weeds, winter annuals (including grasses and broadleaves), and perennial weeds that are not controlled by currently registered herbicides. Because of this, multiple mechanical cultivations are needed, as well as hand weeding near harvest. The cost of cultivation and hand labor drives up production costs.

Diseases

Purple blotch and downy mildew are the most significant diseases and can reduce yields if not controlled. The severity of these infections in leeks is not as great as their infections in onions;

nevertheless, leek growers routinely apply fungicides to control these diseases. Isolated plantings of leek do not have as great a problem with disease.

Critical Pesticide Information

Few herbicides and insecticides are registered for use on leeks. As a result growers are 1) unable to rotate the chemistries of the pesticides they use, which may increase pesticide resistance; 2) forced to use pesticides with limited efficacy, resulting in more frequent use and driving up costs; and 3) unable to effectively control off-label pests.

Insecticides

Compounds representing seven different modes of action (MOA) are registered for leek: two organophosphates; two pyrethroids; two spinosyns; one neonicotinoid; one juvenile hormone mimic; one molting disruptor; and, one microbial disruptor of insect membrane.

Both of the organophosphates provide poor- to moderate control of onion maggot and other targeted pests, suggesting the presence of insecticide resistance. Zeta-cypermethrin (pyrethroid) is the primary insecticide for managing onion maggot flies and thrips, but provides only moderate control. The spinosyns provide good control of caterpillars (secondary pests) but only suppress thrips populations. The neonicotinoid acetamiprid may provide good control of thrips, but is currently not recommended. The same is true for pyriproxyfen, a juvenile hormone mimic. Cyromazine is a molting disruptor of *Diptera* (flies), and is labeled for leafminer control (minor pest) on leek, but not for onion maggot. Although, it would seem that there should be sufficient insecticides to control the primary pests, there are few effective materials.

There are six botanically derived materials and one fungal-based product registered for insect control on leek, but these have not been tested for commercial growers and are not recommended. They include cinnamaldehyde, azadirachtin, potassium salts of fatty acids, *Beauveria bassiana*, capsaicin, potassium silicate, and neem oil.

Herbicides

(This summary does not include the registered materials carfentrazone-ethyl, glyphosate, and paraquat for burn-down of post-emergent weeds or killing culled leeks and residual weeds post harvest. While these materials can be used as post-emergent herbicides for controlling weeds in row middles with hooded nozzles, their use is not recommended because leek rows are narrow and the crop could easily be injured.)

Currently, only three effective herbicide compounds are registered for weed control in the leek standing crop. These are sethoxydim, clethodim, and DCPA, which represent only two chemical classes and modes of action. These materials do not control all the potential weeds found in leek fields, especially galinsoga and pineapple weed. Only DCPA is effective against some broadleaf species.

Fungicides

Current recommendations for foliar-applied fungicides for New Jersey leek growers include five materials, representing four chemical groupings/MOA for the control of purple blotch and

downy mildew. Two of these belong to the strobilurins, FRAC group 11, which rate high for development of disease resistance. Materials in three other FRAC groups—3, 7, and 9—are also registered. Chlorothalonil, FRAC group M5, has a multiple-site MOA and therefore helps prevent disease resistance when alternated with strobilurins on leeks. Chlorothalonil is a valuable protectant fungicide and irreplaceable. Should the chlorothalonil registration be removed from leek production, it would increase the risk of fungicide disease resistance.

IPM Issues

- 1) Management of onion maggot
 - Registered insecticides for both maggot (soil) and flies (foliar) are relatively ineffective.
 - Related crops that are hosts for onion maggot are planted in close proximity to leeks, nullifying the benefits of crop rotation for the East Vineland area.
 - Sanitation (the removal or destruction of culled leeks post-harvest) could help control onion maggot as long as neighboring related crops are treated accordingly.
 - Growers lack a biological control for onion maggot.
 - Effective management depends on eliminating wild alternate hosts.

- 2) Lack of additional herbicides
 - Growers have no effective control for certain broadleaf species, including galinsoga and pineapple weed.
 - Growers rely heavily on mechanical cultivation and hand weeding, which is expensive.

- 3) Potential disease resistance
 - Disease resistance is possible with the strobilurin fungicides, especially if chlorothalonil is lost

Resistance Management Issues

- 1) Apparent resistance or at least tolerance by onion maggot to currently registered insecticides
- 2) Potential disease resistance development to strobilurin fungicides.

Consumer Education Issues – None

Export/Import Issues – None

Pest Profiles

Insect Pests

Overall, insects are the dominant pest concern for leek production. The primary pests, onion maggot and onion thrips, are common where *Allium* species (onion, green onions, shallots, garlic, leek, and chives) are raised, especially in large acreages. Onion maggot has been shown to be resistant to many insecticides, especially the organophosphates. Onion thrips seek out protected areas on plants, such as under leaf sheaths, or where leaves are in close contact, making control with insecticides more difficult.

Isolation of the crop appears to be one of the best alternative means of controlling onion maggot. For the smaller growers who market their leeks through their own farm stands, onion maggot is much less of a concern than for the larger growers or for those whose crops are within a half-mile of other *Allium* crops.

Onion maggot (*Hylemya antiqua*)

This fly belongs to a group of root-feeding flies (family Anthomyiidae) that includes seed corn maggot and cabbage maggot. It is similar in appearance to a housefly, though smaller and more slender. The larvae look like typical fly maggots: spindle-shaped with the head at the small end of the body. Onion maggot has three generations in the northeastern states and is active early in the spring. The flies survive the winter in the pupal stage and emerge in late April to early May. After mating and a pre-ovipositional period, the female flies may lay several hundred eggs on leeks near the soil line. The number of eggs laid depends upon the amount of food that was available for the adults.

Upon hatching, the larvae feed on the plant tissue with mouth hooks. They may kill smaller plants or injure them to the point of being unmarketable. Feeding wounds act as entry points for secondary plant disease pests, such as soft-rot bacteria that cause the leek to decay. Once the

larvae have matured, they molt into the non-feeding pupal stage and remain in the soil near the plant. These pupal capsules are brown and easily found in the soil around the plants. Once mature, the fly breaks open an end of the capsule and crawls up through the soil to the surface, and in a few minutes is ready to fly away.

Onion maggots feed only on onions, leeks, and related plants. Since most leek growers have multiple plantings through the year, onion maggot may be a pest in more than one planting. In contrast, onion maggot is primarily a pest of dry bulb onions only in the spring.

Discarded leeks and onions, or those in cull piles, offer a residual host and help preserve the flies in a local area. Cull piles should be broken up and incorporated into the soil to prevent maggot buildup. Most farmers disc or plow the beds and remaining plants after harvest. Wild onion and wild garlic grow naturally in the state and probably are alternate hosts that sustain onion maggot populations.

Growers rely almost entirely on insecticides to control onion maggot. Onion maggot traps have been used to determine adult activity but identification of flies is difficult and the traps are not used. In the East Vineland area, there is about a month between transplanting leeks to the field and spraying for onion maggot, which commences in mid-April. The blooming of the mustard weed, yellow rocket, is a phenological marker for the onset of onion maggot egg laying. Since leeks can be grown year-round, it can be difficult to eliminate the fly population from a farm.

Threshold: None. The onion maggot fly is endemic to the East Vineland area and so spraying is initiated when the yellow rocket blooms.

Insecticides for use on onion maggot

Currently registered insecticides do not provide good control of onion maggot in New Jersey. New materials need to be tested (IR-4), as well as ones that are registered for use on leeks but are not labeled for onion maggot control, such as cyromazine (Trigard). There is a critical need to find more effective insecticides for onion maggot management.

Organophosphates - IRAC (Insecticide Resistance Action Committee) group 1b

Diazinon – example brand name: Diazinon 50W

- Efficacy – moderate to poor. Used for larval control. Diazinon is soil applied a few days before planting and incorporated into the soil.
- IPM Issues – a broad spectrum insecticide which would kill non-target organisms
- REI – 24 hours
- PHI – NA
- Export/import issues - none
- Why used /not used? Currently, diazinon is the only registered soil insecticide for use on leeks, and currently the only insecticide that has any efficacy against onion maggot larvae.

Malathion

- Efficacy – poor. Used for onion maggot fly control.

- IPM Issues – though relatively non-toxic to humans, it is a broad spectrum insecticide
- REI – 12 hours
- PHI – 3 days
- Export/import issues – none
- Why used/not used? One of the few insecticides registered for use on leeks. Inexpensive.

Pyrethroids - IRAC group 3

Zeta-cypermethrin – example brand name: Mustang Max

- Efficacy – somewhat effective on onion maggot flies.
- Resistance problems – full resistance is likely to result from repeated use
- IPM Issues – a broad spectrum insecticide killing non-target organisms
- REI – 12 hours
- PHI – 7 days
- Export/import issues – none
- Why used /not used? It is used but efficacy is a question on onion maggot. This material is also effective on caterpillars, and at least some activity on thrips and aphids, which represent the primary and most of the secondary insect pests of leeks.

Pest Management Concerns

- Onion maggot is able to develop insecticide resistance, which has been demonstrated in intensive onion production areas around the United States. Given the moderate- to poor control by Malathion, diazinon, and zeta-cypermethrin, tolerance—if not resistance—is developing in the onion maggot population in East Vineland.
- Crop rotation could be an effective control measure since small-scale leek production in northern New Jersey is little affected by onion maggot. However, in the East Vineland area where most leeks are grown, most vegetable farms have small fields of related crops, dry bulb onion, green onion, shallots, and garlic planted in close proximity to leeks. It would be virtually impossible to isolate leeks from other crops by 0.5 mile or more.
- Leeks, especially in East Vineland, have multiple plantings so there is a year-round crop available to onion maggot.
- Sanitation or clean up of culled onions, leeks, and related species is essential to help reduce overwintering populations of onion maggot but it isn't clear how extensively this is done in the East Vineland area.
- There are no known effective biological control agents for onion maggot.

IR-4 Pipeline pest management tools

- Clothianidin – for onion maggot larvae – IRAC group 4a
- Gamma-cyhalothrin – for onion maggot flies - IRAC group 3
- Chlorpyrifos – for onion maggot larvae - IRAC group 1b
- Application for a section 18 exemption for clothianidin in 2009 on leeks as a seed treatment for onion maggot control

Needs

Regulatory

- Registration of effective insecticides for onion maggot control, primarily for controlling the larval stage; secondarily for the onion maggot flies

Research

- Develop a bait trap for controlling onion maggot flies

Education - None

Onion thrips (*Thrips tabaci*)

Thrips are small, 1/8 inch long, herbivorous insects that feed on the cuticle of plants rasping away the plant tissue and then sucking up the plant fluids. Thrips feeding damage can slow the growth of leeks and help dehydrate the plants. The feeding damage also discolors the leaves, making them less appealing and thus less marketable. Because leeks have a thicker cuticle than onion cuticles, they are less susceptible to thrips injury.

Both adult and immature thrips congregate between the leaf stalks and sheaths, preferring protected, tight places, especially near top of the bulb at the leaf base. Because of this shelter, insecticidal treatments rarely eliminate thrips.

Eggs are inserted into the plant and upon hatching, the immatures begin feeding on the plant cuticle. After the second instar, the thrips pupate in the soil and return to the plant once they mature to the adult stage. There are six to ten generations a year depending upon seasonal temperatures. Dry, warm weather favors the development of thrips populations. As grass weeds dry up, resident thrips migrate to other hosts.

Onion thrips are polyphagous, surviving on many different crop and weed species. As a result, there is greater reliance upon insecticide use for controlling thrips, since weed management isn't likely to help reduce their numbers.

Growers who raise green onions watch for the presence of thrips on the onions and then initiate insecticides for thrips control on leeks. Green onions are a preferred host and thrips will infest these prior to leeks.

Threshold: Presence of thrips, especially in the spring.

Insecticides for use on onion thrips

Labeled insecticides include Mustang Max (zeta-cypermethrin); Entrust and Spintor (spinosad); Radiant (spinetoram); deltamethrin and malathion. Of these, zeta-cypermethrin is probably the most effective at managing thrips populations. While spinosad and spinetoram products are labeled for thrips, they only suppress populations. Malathion is not effective for thrips control. Despite the risk of developing insecticide resistance, zeta-cypermethrin is the primary material growers use for thrips control.

Pyrethroids - IRAC group 3

Zeta-cypermethrin – example brand name: Mustang Max

- Efficacy – somewhat effective on onion thrips
- Resistance problems – eventual resistance is likely with repeated use

- IPM Issues – a broad spectrum insecticide killing non-target organisms
- REI – 12 hours
- PHI – 7 days
- Export/import issues – none
- Why used /not used? It is probably the most effective insecticide available on onion thrips. This material is also effective on caterpillars, and has some activity on onion maggot flies and aphids, which represent the primary and most of the secondary insect pests of leeks.

Deltamethrin – example brand name: Battalion 0.2 EC

- Efficacy - Generally not used. Efficacy unknown.
- Resistance problems – potential for resistance since the primary material used is also a pyrethroid
- IPM Issues – a broad spectrum insecticide
- REI – 12 hours
- PHI – 1 day
- Export/import issues – none?
- Why used /not used? Has not been used by growers or only on a limited basis. Other materials are available which may be more cost effective. It is not a recommended insecticide for thrips control.

Spinosyns - IRAC group 5

Spinosad – example brand name: Entrust

- Efficacy – suppression of thrips, only
- Resistance problems – not likely to occur
- IPM Issues – a broad spectrum insecticide, less toxic to some predators but highly toxic to parasitic hymenoptera (wasps)
- REI – 4 hours
- PHI – 1 day
- Export/import issues – none
- Why used /not used? It is a thrips material for leeks, but only suppresses thrips. It does control caterpillars well, but caterpillars are rare pests on leeks.

Spinetoram – example brand name: Radiant

- Efficacy – suppresses thrips only
- Resistance problems – resistance not likely to occur
- IPM Issues – a broad spectrum insecticide, less toxic to some predators but highly toxic to parasitic hymenoptera (wasps)
- REI – 4 hours
- PHI – 1 day
- Export/import issues – none
- Why used /not used? It is a thrips material for leeks, but only suppresses thrips. It does control caterpillars well, but caterpillars are rare pests on leeks.

Organo-phosphates - IRAC group 1b

Malathion

- Efficacy – poor control of thrips
- Resistance problems – possible tolerance of thrips to malathion
- IPM Issues – a broad spectrum insecticide
- REI – 12 hours
- PHI – 3 days
- Export/import issues – none
- Why used /not used? Malathion is not used or rarely because there are better materials to use. Malathion provides poor control of thrips.

Neonicotinoids - IRAC group 4a

Acetamiprid – example brand name: Assail

- Efficacy – Good?
- Resistance problems – resistance not likely to occur
- IPM Issues – none
- REI – 12 hours
- PHI – 7 days
- Export/import issues – none
- Why used /not used? Price may be a factor and it may be a relatively new label. Growers may not be aware of it as it is not included in the commercial recommendations. However, it is labeled only for thrips while zeta-cypermethrin also has some effect on the onion maggot flies.

Juvenile hormone mimics – IRAC group 7c

Pyriproxyfen – example brand name: Knack

- Efficacy – suppresses thrips
- Resistance problems – resistance not likely to occur
- IPM Issues – a selective insecticide affecting only the immature stages, including non-targets
- REI – 12 hours
- PHI – 3 days
- Export/import issues – none
- Why used /not used? It is a thrips material for leeks, but only suppresses thrips. Not included in the commercial recommendations.

Other materials

The following materials are registered on leeks for control of thrips. They are, however, untested materials and their effectiveness is unknown; consequently they are not recommended for commercial leek production.

Cinnamaldehyde

Azadirachtin

Potassium salts of fatty acids

Beauveria bassiana

Potassium silicate

Neem oil

Pest Management Concerns

- Onion thrips are difficult to control because of their secretive habits, which limits direct exposure to insecticides. Further, thrips populations can develop tolerance to insecticides. Because of these factors, more insecticide applications are needed to manage thrips below economic injury. Fortunately, leeks have thicker leaf cuticles than related crops and are less prone to injury.
- In East Vineland, leeks can be easily re-infested because of the proximity of other related crops, as well as weed hosts around the field.
- Poor weed control in the leeks will favor the development of thrips populations, impeding good insecticide coverage on the leaves.

IR-4 Pipeline pest management tools

- Gamma-cyhalothrin – IRAC group 3
- Dinotefuran – IRAC group 4a
- Methyl-parathion – IRAC group 1b

Needs

Regulatory

- Register effective thrips materials.

Research

- Evaluate acetamiprid for thrips control on leeks.

Education

- Include acetamiprid products in commercial recommendations, providing that research indicates that acetamiprid is as good or better than currently used materials

Minor Insect Pests

European corn borer (*Ostrinia nubilalis*)

The European corn borer (ECB) is a rare pest of leeks that only feeds on leeks in late summer or fall. Typically, there are two generations of the dominant ECB strain, with a partial third generation in late summer and early fall. This late generation feeds on many atypical hosts including leeks. Initially larvae feed on the outer cuticle of the leaves, but then bore into the leaves and continue feeding inside the leaf, out of reach of insecticides. Therefore, control must be achieved before the caterpillars enter the leaves.

Fall armyworm (*Spodoptera frugiperda*)

Fall armyworm (FAW) is a migratory pest that comes into New Jersey in early to mid summer and typically feeds on grasses, but will feed on various broadleaf weeds and crops including leeks, though this is very rare. FAW caterpillars behave similar to ECB larvae and must be controlled before they enter the hollow leaves.

Other caterpillars

Cabbage looper, yellow striped armyworm, and various cutworm species are other pests that may appear in leeks.

All of the caterpillars are susceptible to zeta-cypermethrin, which is widely used by leek growers on a routine application schedule. As a result, most of the potential caterpillar pests are eliminated before economic damage is done.

Aphids

Even though aphids are listed as a pest of leeks in the New Jersey commercial recommendations book, aphids are not usually pests of leeks, and no growers surveyed for the New Jersey crop profile identified aphids as leek pests. Zeta-cypermethrin is labeled for use on aphids in leeks.

Pest Management Concerns for minor pests - None

IR-4 Pipeline pest management tools - None

Needs

Regulatory - None

Research - None

Education - None

Weed Pests

Weeds are problematic for leeks in that they compete directly with leeks for soil nutrients, water, and space. Additionally, they serve as reservoirs for various pests, such as thrips and caterpillars, and reduce the effectiveness of pesticide applications by preventing good coverage. All weeds occurring in a leek field can be considered pests; the most difficult weed species, however, are those that the registered herbicides do not control. For those species, growers must mechanically cultivate the crop several times and resort to hand weeding as harvest approaches.

Weeds can be separated into three groups: winter annuals, summer annuals, and perennials. Both grass and broadleaf species occur in each group. There are also annual and perennial sedges, which require special herbicide compounds for control.

Winter annuals are those weeds that germinate in the late summer or fall and overwinter in a dormant, vegetative stage. With the onset of increasing temperatures, the plants resume growing and go to seed by May or early June. These weeds can be a problem for early spring plantings of leeks as well as the overwintered leeks.

Summer annual weeds germinate in mid- to late spring and go to seed by mid- to late summer. These species are pests of leeks in the field during the bulk of the growing season.

Perennial weeds (including sedges) live during two or more growing seasons. These weeds are especially difficult to eliminate and should not be allowed to become established in uninfested fields. Fields infested with perennials may have to be set aside so that appropriate herbicides can be used against them without endangering crops, or a grower may need to rotate to crops for which registered herbicides that can be used on perennials exist.

Winter annual post-emergent herbicides for the standing leek crop

Cyclohexanediones - WSSA (Weed Science Society of America) Group 1

Sethoxydim – example brand name: Poast

- Efficacy – Good grass control
- Resistance problems – not likely, though growers tend to rely on sethoxydim for grass control
- IPM Issues - none
- REI – 12 hours
- PHI – 30 days
- Export/import issues – none
- Why used /not used? Sethoxydim provides good control of grasses only, without fear of crop damage. Sethoxydim can be used on most leek growth stages.

Clethodim – example brand name: Clethodim 2E

- Efficacy – Good grass control
- Resistance problems – not likely although clethodim belongs to the same chemical group as sethoxydim
- IPM Issues - none
- REI – 24 hours
- PHI – 14 days
- Export/import issues – none
- Why used /not used? Not in current commercial recommendations. Most commercial growers rely on sethoxydim.

Summer annual post-emergent herbicides for the standing leek crop

Cyclohexanediones - WSSA Group 1

Sethoxydim – example brand name: Poast

- Efficacy - Good

- Resistance problems – not likely, though growers tend to rely on sethoxydim for grass control
- IPM Issues - none
- REI – 12 hours
- PHI – 30 days
- Export/import issues – none
- Why used /not used? Sethoxydim provides good control of grasses without fear of crop damage. Sethoxydim can be used on most leek growth stages.

Clethodim – example brand name: Clethodim 2E

- Efficacy - Good
- Resistance problems – not likely although clethodim belongs to the same chemical group as sethoxydim
- IPM Issues - none
- REI – 24 hours
- PHI – 14 days
- Export/import issues – none
- Why used /not used? Not in current commercial recommendations. Most commercial growers rely on sethoxydim.

Winter and summer annual grass and broadleaf pre-emergent herbicides (soil treatment)

Benzoic acid – WSSA Group 3

DCPA – example brand name: Dacthal Flowable

- Efficacy – Good on certain grass and broadleaf weed species
- Resistance problems – possible since current broadleaf control in leeks hinges on the use of dacthal; resistance unlikely in grass species, since sethoxydim is also used, which is in a different group mode of action
- IPM Issues - none
- REI – 12
- PHI - NA
- Export/import issues – none
- Why used /not used? Dacthal is the primary herbicide for leek production, in part, because it is the only herbicide registered for broadleaf weed control that doesn't risk crop injury.

Chloroacetemide – WSSA group 15

Dimethenamid-p – example brand name: Outlook

- Efficacy – Good on certain grass and broadleaf weed species
- Resistance problems – not likely to occur because of the mode of action is different from other registered herbicides
- IPM Issues - none
- REI – 12
- PHI - NA
- Export/import issues – none

- Why used /not used? Although labeled for leeks in New Jersey, in plot work, it was found that dimethenamid-p caused crop damage on coarse soils, where the majority of leeks are grown. It is not recommended to commercial growers.

Pest Management Concerns

- Dacthal is the only effective registered broadleaf weed herbicide for use in leeks. If the dacthal label for leeks is lost there is no replacement material for broadleaf control
- Register new herbicides for leek weed control
- Develop new strategies for weed management

IR-4 Pipeline pest management tools

- S-metolachlor (Dual Magnum)

Needs

Regulatory

- Expand the label for S-metolachlor to include leek for broadleaf weed control
- Expand the labels of other herbicides registered for use in dry bulb onions to include leek, especially for the control of galinsoga and pineapple weed and other broadleaf weeds currently not controlled by dacthal.

Research – None

Education – None

Perennial weeds

Common perennial weeds in New Jersey include horsenettle, Canada thistle, milkweed, hemp dogbane, johnsongrass, and yellow nutsedge. Currently, there is no registered, effective herbicide for these perennials in the standing crop. Burn-down and systemic herbicides can be used post-harvest, or when the field is fallow. These weeds are zero tolerance weeds and should be removed immediately when new infestations are found in otherwise uninfested fields.

Disease Pests

Purple blotch and downy mildew are the primary diseases occurring annually on leeks in New Jersey. Minor diseases include white rot, whose development depends, in part, on whether sclerotia are surviving from previous years' infestations and pink root, which occurs infrequently. As a result, few fungicides are recommended for disease control in leeks.

Purple blotch (*Alternaria porri*)

The fungus overwinters on infested plant debris. Warm (77°F to 85°F), moist weather favors development and spread of the disease. Purple blotch attacks the leaves of leeks causing an oblong lesion with distinct concentric rings. As conidia (spores) develop, the rings darken. Initial

infections start with injured tissue caused by hail, insect feeding, or other factors. Impact of purple blotch can be minimized by rotating the crops and destroying infected plant debris.

Purple blotch also attacks onions and related crops. Infections in these crops allow for the spread of spores to nearby leek fields. Dense plantings of leeks favor the disease, but it is impractical to cut back on planting densities. Post-harvest, culled leeks, and plant debris should be disked or plowed under to prevent reinfection of nearby host crop plantings.

Purple blotch is as much a cosmetic disease as it is a debilitating disease. Leeks are sold as fresh market produce. The presence of disease lesions on the leaves would reduce the marketability of the bunches. (Leeks are sold in bunches with 3 to 4 leeks per bunch.)

Fungicide applications should begin as soon as transplants are in the field. Growers should alternate a protectant fungicide with an eradicant fungicide at 10-day intervals as long as night temperatures are warm. A recommended fungicide program is as follows:

Chlorothalonil (FRAC code M5) at 1.5 to 3 pt 6F/A; (do not apply chlorothalonil more than three times per season)

With one of the following fungicides:

Quadris (azoxystrobin, 11) at 6.2 to 12.3 fl oz 2.08F/A, or
Pristine (pyraclostrobin + boscalid, 11 + 7) at 10.5 to 18.5 oz 38WP/A, or
Endura (boscalid, 7) at 6.8 oz 70WG/A

This rotation affords good protection of the plants and reduces the risk of fungicide resistance in the purple blotch pathogen.

Threshold: advent of warm, moist (rainy or heavy dew) weather

Fungicides registered for use on leeks for controlling purple blotch

Strobilurins – FRAC (Fungicide Resistance Action Committee) group 11

Pyraclostrobin – example brand name: Cabrio

- Efficacy - Works well but is expensive.
- Resistance problems - It should be used alternating with chlorothalonil to prevent the development of resistance.
- IPM Issues – single site mode of action
- REI – 12 hours
- PHI – 7 days
- Export/import issues – none
- Why used /not used? This is a relatively new product and growers may be satisfied with the standard disease treatments that they have been using.

Azoxystrobin – example brand name: Quadris

- Efficacy - similar in efficacy to pyraclostrobin.

- Resistance problems - It is recommended to alternate its use with chlorothalonil to manage resistance.
- IPM Issues – single site mode of action
- REI – 4 hours
- PHI – 0 day
- Export/import issues – none
- Why used /not used? This is one of the standard materials used by leek growers.

Fenamidone – example brand name: Reason

- Efficacy - similar in efficacy to pyraclostrobin.
- Resistance problems - It is recommended to alternate its use with chlorothalonil to manage resistance.
- IPM Issues – single mode of action
- REI – 12 hours
- PHI – 7 days
- Export/import issues – none
- Why used /not used? Not sure. Newer material and maybe leek growers are not aware of it. It is recommended for use by commercial growers.

Chloronitriles – FRAC group M5

Chlorothalonil – B2 carcinogen – example brand name: Bravo

- Efficacy – Good material, effective.
- Resistance problems – It is needed to manage or delay resistance to strobilurin fungicides.
- IPM Issues
- REI – 12 hours
- PHI – 14 days
- Export/import issues - none
- Why used /not used? It is less expensive than the strobilurin fungicides. It is one of the fungicidal standards.

Pyridine-carboxamides – FRAC group 7

Boscalid – example brand name: Endura

- Efficacy – Good material, effective.
- Resistance problems – a protectant but in a different FRAC group from chlorothalonil. It is needed to compliment chlorothalonil to manage or delay resistance to strobilurin fungicides.
- IPM Issues - none
- REI – 12 hours
- PHI – 7 days
- Export/import issues - none
- Why used /not used? Currently not being used by leek growers who rely mostly on chlorothalonil for a protectant fungicide. It is recommended for commercial growers.

Cinnamic acid amides – FRAC group 40

Dimethomorph – example brand name: Forum

- Efficacy – Good
- Resistance problems – not likely as it belongs to a different chemical/mode of action group
- IPM Issues - none
- REI – 12 hours
- PHI – 0 days
- Export/import issues - none
- Why used /not used? Currently not being used by leek growers who rely mostly on chlorothalonil for a protectant fungicide. It is recommended for commercial growers.

Anilino-Pyrimidines – FRAC group 9

Pyrimethanil – example brand name: Scala SC

- Efficacy – Good
- Resistance problems – not likely as it belongs to a different chemical/mode of action group
- IPM Issues - none
- REI – 12 hours
- PHI – 7 days
- Export/import issues - none
- Why used /not used? Currently not being used by leek growers who rely mostly on chlorothalonil for a protectant fungicide. It is recommended for commercial growers.

Triazoles – FRAC group 3

Propiconazole – example brand name: Propimax EC

- Efficacy – Good
- Resistance problems – medium risk for disease resistance, however these fungicides appear to be little used on leeks
- IPM Issues - none
- REI – 24 hours
- PHI – 0 days
- Export/import issues - none

Why used /not used? Growers may not be aware of this material. Currently not in recommendations for commercial growers.

Tebuconazole – example brand name: Folicur 3.6

- Efficacy – Good
- Resistance problems – medium risk for disease resistance, however these fungicides appear to be little used on leeks
- IPM Issues - none
- REI – 12 hours
- PHI – 7 days
- Export/import issues - none

Why used /not used? Growers may not be aware of this material. Currently not in recommendations for commercial growers.

Other materials for controlling purple blotch

The following materials are registered for control of purple blotch in leeks for New Jersey. These materials have not been tested, however, and cannot be recommended at this time.

Mono-, and dipotassium phosphate

Neem oil

Carbonic acid

Hydrogen dioxide

Octanoic acid

Pest Management Concerns

- Growers should rotate chemical classes of fungicide to avoid disease resistance.
- Traditional use by growers of particular pesticides, especially chlorothalonil, may slow their acceptance of additional protectant fungicides.

IR-4 Pipeline pest management tools - None

Needs

Regulatory

- Review fungicides currently labeled for onions for possible registration on leeks

Research - None

Education

- Update commercial recommendations to include more registered materials.

Downy mildew (*Peronospora destructor*)

Downy mildew infects leeks and other *Allium* species world-wide and is one of the most important diseases of leeks. Small, pale, white oval lesions develop on older leaves, and as the number of lesions increase leaves begin to wilt. Warm, moist weather (77°F to 85°F) that favors purple blotch development also favors downy mildew development. Downy mildew may overwinter in plant debris and culled bulbs. The fungus doesn't need injured tissue for initial infections but field observations support the idea that a higher infection of downy mildew is often associated with an increased presence of thrips.

Growers rely on pesticides for control almost exclusively. Fungicide applications begin as soon as transplants are set out as long as night temperatures are warm. Protectant and eradicant fungicides should be alternated on a ten-day schedule: Forum (dimethomorph, 40) at 6 fl oz 4.18SC/A (must be tank mixed with another fungicide effective for downy mildew) + chlorothalonil (M5) at 1.5 to 3 pt 6F/A or OLF (do not apply chlorothalonil more than three times per season) with Quadris (azoxystrobin, 11) at 9.2 to 15.4 fl oz 2.08F/A, or Cabrio (pyraclostrobin, 11) at 8 to 12 oz 20EG/A, or Pristine (pyraclostrobin + boscalid, 11 + 7) at 18.5 oz 38WP/A for downy mildew suppression,

Crop rotation and destruction of leek and onion culls are the best alternative/cultural control practices, the results of which are somewhat limited in the East Vineland area.

Threshold: advent of warm, moist weather

Fungicides registered for use on leeks for controlling downy mildew

Strobilurins – FRAC group 11

Pyraclostrobin – example brand name: Cabrio

- Efficacy - Works well but is expensive.
- Resistance problems - It should be used alternating with chlorothalonil to prevent the development of resistance.
- IPM Issues – single site mode of action
- REI – 12 hours
- PHI – 7 day
- Export/import issues – none
- Why used /not used? This is a relatively new product and growers may be satisfied with the standard disease treatments that they have been using.

Azoxystrobin – example brand name: Quadris

- Efficacy - similar in efficacy to pyraclostrobin.
- Resistance problems - It is recommended to alternate its use with chlorothalonil to manage resistance.
- IPM Issues – single site mode of action
- REI – 4 hours
- PHI – 0 day
- Export/import issues – none
- Why used /not used? This is one of the standard materials used by leek growers.

Fenamidone – example brand name: Reason

- Efficacy - similar in efficacy to pyraclostrobin.
- Resistance problems - It is recommended to alternate its use with chlorothalonil to manage resistance.
- IPM Issues – single site mode of action
- REI – 12 hours
- PHI – 7 days
- Export/import issues – none
- Why used /not used? Not sure. Newer material and maybe leek growers are not aware of it. It is recommended for use by commercial growers.

Chloronitriles – FRAC group M5

Chlorothalonil – B2 carcinogen – example brand name: Bravo

- Efficacy – Good material, effective.
- Resistance problems – It is needed to aid in resistance management of strobilurin fungicides.
- IPM Issues

- REI – 12 hours
- PHI – 14 days
- Export/import issues - none
- Why used /not used? It is less expensive than the strobilurin fungicides. It is one of the fungicidal standards.

Cinnamic acid amides – FRAC group 40

Dimethomorph – example brand name: Forum

- Efficacy – Good
- Resistance problems – not likely as it belongs to a different chemical/mode of action group
- IPM Issues - none
- REI – 12 hours
- PHI – 0 days
- Export/import issues - none
- Why used /not used? Currently not being used by leek growers who rely mostly on chlorothalonil for a protectant fungicide. It is recommended for commercial growers.

Mandipropamid – example brand name: Revus

- Efficacy – Good
- Resistance problems – not likely as it belongs to a different chemical/mode of action group
- IPM Issues - none
- REI – 12 hours
- PHI – 7 days
- Export/import issues - none
- Why used /not used? Currently not being used by leek growers who rely mostly on chlorothalonil for a protectant fungicide. It is recommended for commercial growers.

Other materials

The following pesticides are labeled for downy mildew control in leeks for New Jersey, but they have not been tested. Their efficacy is in doubt and they are not recommended.

Mono-, and dipotassium phosphate

Neem oil

Carbonic acid

Hydrogen dioxide

Octanoic acid

Pest Management Concerns

- Growers should rotate chemical classes of fungicide to avoid disease resistance.
- Traditional use by growers of particular pesticides, especially chlorothalonil, may slow their acceptance of additional protectant fungicides.

IR-4 Pipeline pest management tools - None

Needs

Regulatory

- Review fungicides registered for onion to see if these can or should be registered for leeks.

Research - None

Education

- Expand the leek section in the commercial recommendations to include more currently registered and effective materials.

Minor disease pests

White rot (*Sclerotium cepivorum*)

White rot is a soil-borne fungal disease that causes leaves to wilt and bulbs to disintegrate. Exudates from the roots of leeks cause overwintering sclerotia to germinate and produce small mushrooms, which release spores for infecting leeks. The spores infect plant tissue near the soil line. As the fungus grows a white mycelial mat may be visible on the infected tissue. Small, hard, black sclerotia develop within the mycelia and remain viable in the soil for many years.

White rot development is favored by cool (50°F to 75°F), wet soil conditions. Because of this, early spring plantings and over-wintering leeks are most susceptible to white rot. Southern transplants should not be used, as these are often already infected upon arrival in New Jersey. Fumigation may help to kill overwintering sclerotia in the soil. White rot is a minor disease of leeks in New Jersey. However, the severity of white rot development in any given field depends on both the presence of favorable weather and soil conditions and the amount of viable sclerotia in the soil from previous infestations of the disease.

Avoidance of the infection is the best alternative control. Long term rotation, up to 4 years, is useful in reducing white mold infections.

Threshold: presence of the disease within the past 4 years for fumigation; no recommendation in the current season.

Fungicides registered for use on leeks for controlling white mold

Strobilurins – FRAC group 11

Azoxystrobin – example brand name: Quadris

- Efficacy – moderate?
- Resistance problems – not likely to occur with white mold. Not many growers have problems with this disease.
- IPM Issues – single site mode of action
- REI – 4 hours
- PHI – 0 day
- Export/import issues – none

- Why used/not used? For effective control of white mold a fungicide has to be applied prior to infection. Quadris is already being used for protection against purple blotch and downy mildew.

Pest Management Concerns

- Ability to use long term crop rotation.

IR-4 Pipeline pest management tools - None

Needs

Regulatory

- Review fungicides registered for onion for white mold control to see if these can or should be registered for leeks.

Research - None

Education - None

Pink root (*Phoma (Pyrenochaeta) terrestris*)

This minor fungal disease attacks the roots of leeks and a wide range of other vegetable crops. Infected roots wither and die, turning a light pink. Heavy, damp soils with low organic matter are most susceptible to severe infections; the fungus, however, remains active over a range of moisture levels. Infections can occur in a temperature range of 60°F to 90°F with an optimal temperature of 79°F. Severe infections reduce the viability of the infected plants by continually killing newly-grown roots. Leeks are generally tolerant of the fungus. Soil fumigation may help to control the disease.

No leek grower is known to apply pesticides for the control of pink root. If a severe infection of pink root were found, long-term rotation of all Allium species would be the primary recommendation. Growers would be discouraged from purchasing and using southern transplants. And if it were warranted, soil fumigation could be used, but it's not clear how effective fumigation would be in killing the fungal pathogen.

Threshold: none

Fungicides registered for use on leeks for controlling pink root - None

Pest Management Concerns

- Ability to use long-term crop rotation devoid of Allium crops

IR-4 Pipeline pest management tools - None

Needs

Regulatory – None

Research

- Evaluate soil fumigants for efficacy and potential registration.

Education – None

Soil-borne diseases – Rhizoctonia and Pythium damping off

These diseases are general soil-borne pathogens that attack a broad range of plant hosts. Usually damp, cool soil conditions favor their development. Seed treatments and soil treatments with fungicidal materials offer the best protection against these diseases. Growers find transplants occasionally having soil-borne disease problems, both in the greenhouse and field seed bed. Currently, azoxystrobin and fludioxonil are registered as soil treatments and mefenoxam and azoxystrobin as seed treatments for these diseases.

Threshold: None. Prevention of the problem is critical. Once infected plants are found, it is too late for a rescue treatment.

Fungicides registered for use on leeks for controlling soil-borne diseases

Strobilurins – FRAC group 11

Azoxystrobin – example brand name: Quadris

- Efficacy – good on Rhizoctonia only
- Resistance problems – not likely, since this treatment would be a soil application at planting or used as a seed treatment
- IPM Issues – single site mode of action
- REI – 4 hours
- PHI – 0 day
- Export/import issues – none
- Why used /not used? Few growers have indicated a problem with growing of greenhouse transplants with Rhizoctonia or other soil-borne diseases.

Phenylpyrroles – FRAC group 12

Fludioxonil- example brand name: Maxim 4FS

- Efficacy – good, on Rhizoctonia only
- Resistance problems – low to medium risk
- IPM Issues
- REI – 12 hours
- PHI – NA
- Export/import issues – none
- Why used /not used? Few growers have indicated a problem with growing of greenhouse transplants with Rhizoctonia or other soil-borne diseases.

Phenylamides – FRAC group 4

Mefenoxam – example brand name: Apron XLS

- Efficacy – good, used as a seed treatment effective against Pythium damping off
- Resistance problems – resistance and cross resistance found in this chemical group
- IPM Issues
- REI – 48 hours, unless the mefenoxam in soil incorporated so that workers will not be exposed to treated materials
- PHI – NA
- Export/import issues – none
- Why used /not used? Few growers have indicated a problem with growing of greenhouse transplants with Rhizoctonia or other soil-borne diseases.

Pest Management Concerns - None

IR-4 Pipeline pest management tools - None

Needs

Regulatory - None

Research - None

Education - None

Post-harvest diseases

Occasionally harvested bunches of leeks succumb to fungal infections (one or more species?) that are more likely to be opportunistic pathogens, becoming established in bruised tissue in the process of harvesting and preparation for market. It was suggested at the PMSP meeting that the material Oxidate could be beneficial for preventing this type of disease infection.

No label currently exists for this use of Oxidate. However, it is labeled for application to the handling surfaces of production equipment in enclosed areas, for example, greenhouses.

Needs

Regulatory – None

Research

- Determine if Oxidate is effective in preventing post-harvest disease infections.

Education - None

Nematode Pests

Nematodes are not pests of leeks in New Jersey.

Vertebrate Pests

White-tailed deer

Deer are rarely a pest in leeks. No specific activity is performed to control deer except for hunting.

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