OREGON STATE UNIVERSITY EXTENSION SERVICE

An Integrated Pest Management Strategic Plan for

# Treasure Valley Onions

## in Oregon and Idaho

Katie Murray, Stuart Reitz and Paul Jepson

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# Introduction

## Process for this IPM Strategic Plan (“IPMSP”)

In a proactive effort to identify pest management priorities and lay a foundation for future strategies and increased use of Integrated Pest Management in onions, growers, commodity-group representatives, pest control advisors, university specialists, and other technical experts from the Treasure Valley in Oregon and Idaho formed a work group and assembled this document, *IPMSP for Treasure Valley Onions*. Members of the group met for a day in November 2016 and a day in February 2017 in Ontario, Oregon, where they discussed and reached consensus on this document.

This plan outlines major pests, current management practices, critical needs, activity timetables and efficacy ratings of various management tools for specific pests in onion production. Workgroup members met again in February 2019 in Ontario to revise and update the original document. The result is an up-to-date, comprehensive strategic plan that addresses many pest-specific critical needs for the Treasure Valley onion industry.

The 2019 list of top-priority critical needs reflects changes since 2016. A list of broader IPM needs is also included, which summarizes needs for IPM-specific topics. Crop-stage-specific critical needs are also listed and discussed throughout the body of the document.

This publication provides an overview of onion production, followed by a discussion of critical production aspects and the basics of IPM in onion production in this region. Each pest is described briefly, with links provided for more information on the biology and life cycle of each pest. Within each major pest grouping, individual pests are presented in alphabetical order, not in order of importance.

The remainder of the document analyzes management practices and challenges, organizing them by crop life stage so growers understand whole-season management practices and constraints. Current management practices are presented using a “Prevention, Avoidance, Monitoring, Suppression” (PAMS) framework. This puts practices within a simple IPM classification and identifies areas where additional tools or practices may be needed. For more information on PAMS, see the Appendix titled “Using PAMS Terminology.”

Trade names for certain pesticides are included as an aid for the reader. The use of trade names does not imply endorsement by the work group or any of the organizations represented.

**About the authors**

Katie Murray, program leader for IPM Engagement and Implementation, Integrated Plant Protection Center, and assistant professor of practice, Department of Environmental and Molecular Toxicology; Stuart Reitz, county leader, Malheur County Extension, and professor, Department of Crop and Soil Science; and Paul Jepson, director of Integrated Plant Protection Center and professor, Department of Environmental and Molecular Toxicology; all of Oregon State University.

# Work group members: 2019 revision

## In attendance

Ted Buhrig, Farmers Supply Co-op
Scott Cruickshank, Cruickshank Farms
Joel Felix, Oregon State University
Keven Froshiesar, ProGro West
Bruce Hunter, Valley Agronomics
Leighton Keller, Farmers Supply Co-op
Luke Keller, Simplot Grower Solutions
Tim Kurth, Farmers Supply Co-op
Glenn Letendre, Syngenta
Corey Maag, Y-1 Farms, Jamieson Produce
Stuart Reitz, Oregon State University
Steve Saito, Saito Farms, Malheur County Onion Growers Association
Bob Simerly, McCain Foods
Christy Tanner, Oregon State University
Brian Taylor, Skeen Farms
James Woodhall, University of Idaho, Parma
Kris Yano, Yano Farms

## Others in attendance

Al Fournier, Arizona Pest Management Center, University of Arizona
Paul Jepson, Integrated Plant Protection Center, Oregon State University
Katie Murray, Integrated Plant Protection Center, Oregon State University

## Contributing work group members not in attendance at workshop

Mike Thornton, University of Idaho

# Top-priority critical needs

The following critical needs — voted as the top-priority needs by the work group members present at the initial 2016–17 meetings — were updated in 2019. Crop-stage-specific aspects of these needs, as well as additional needs, are listed and discussed throughout this publication.

## Research topics

- Effective yellow nutsedge management practices.
- *Fusarium proliferatum*, including understanding the ecology and epidemiology of the pathogen to determine control measures, identify alternate hosts, and assess the impact of temperature on disease progression.
  - ❏ **2019 update:** Ecology and epidemiology are better understood, but more research is needed to identify host crops (e.g., corn), to determine the extent of infection versus misidentification with other infections (e.g., is it being confused with *botrytis* neck rot?), and method of infection in onions.
- Early, in-season and storage detection of onion diseases and bulb rot.
- Factors that contribute to secondary pest outbreaks; conservation of parasitoids is needed for leafminers to prevent secondary pest outbreaks.
- Development of an areawide monitoring program for thrips and iris yellow spot virus.**2019 update:** This work is underway.

## 2019 new research topics

- Strategic and long-term planning for pink root management, including the development of alternative management methods and more research on the biology of the disease.
- Increase research on scouting and the use of advanced technologies to support pest management decision-making (for example, drones, satellite, remote-sensing and predictive models).
- Research on the use of cover crops and impacts on pest complex and management.

## Regulatory actions

- Establish formal communication with the EPA by the onion industry and affiliated researchers regarding the importance of avoiding pesticide risk trade-offs. Lower-risk but less-efficacious products may confer higher overall risks because they are used at increased frequencies compared with the higher toxicity but efficacious products that they replaced.

❏ **2019 update:** This is an ongoing need, but the Treasure Valley onion industry regularly attends regulator meetings and discusses critical needs.

- Allow growers more options for late-season control of thrips, such as a Special Local Needs label for carzol for late-season control to reduce reliance on methomyl (Lannate).

❏ **2019 update:** The industry is making progress in reducing reliance on methomyl. The effort to support a Special Local Needs request is ongoing.

- Pursue IR-4 applications for bulb mite field trials to add bulb mite to product labels for in-season control in onions (such as vydate, azadirachtin).
- Increase patent lengths to raise the incentive for manufacturers to manage and maintain critical active ingredients in the marketplace.

    - Increase communication with regulatory agencies and congressional representatives (tours, education, etc.) to improve their understanding of agricultural production practices.

## 2019 new regulatory topics

- Continued pursuit of effective chemistries for nutsedge suppression.

## Education

- Educate and motivate seed companies to locate onion seed fields away from commercial onion production as a means to reduce the "green bridge" between these crops for onion thrips and iris yellow spot virus.
    - ❑ **2019 update:** Meetings with seed company representatives took place, but this is an ongoing issue.
- Sustain areawide monitoring and alerts for thrips and iris yellow spot virus.
- Increase resistance-management education.
    - ❑ **2019 update:** An education workshop was conducted last year for Treasure Valley onion growers on this topic. Resistance management and monitoring remains an important issue.
- Educate growers on the importance of soil testing for nematodes.
- Educate custom applicators on the importance of cleaning equipment between fields.

## 2018 new education topics

- Ensure awareness of emerging diseases and pests.
- Increase education to home gardeners and Master Gardeners on challenging pests (e.g., white rot); increase public awareness about the need for control of major onion pests.

# Treasure Valley onion production overview

There are approximately 24,000 total dry bulb onion acres in the Treasure Valley, with approximately 13,000 of these acres in Oregon and 11,000 acres in Idaho. Most farms produce from 80 to 400 acres of onions annually. This region produces an annual farm gate value of $110 million to $140 million and accounts for 30 percent of U.S. dry bulb onion production. Current net yields average about 860 cwt (100-pound bags) per acre (43 tons per acre), and production costs are approximately $5,000 per acre. The Treasure Valley's onions are known as "Sweet Spanish" onions.


In the Treasure Valley, onions are grown on a range of mineral soils. Sandy-loam or silt-loam soils are preferred. Soils are mostly silt loam and slightly alkaline, with a pH around 7.5. Growers have adopted tactics such as soil and tissue sampling to optimize fertilization.

Onions in this region are planted in March and April, with a harvest time of August through early October. Most growers try to use 4- to 5-year rotations, but the sequence of crops in rotations varies. Common rotational crops include dry beans, field corn, sugar beets, potatoes and wheat.

Most onion fields in the Treasure Valley are fumigated in the fall before onions are planted to help control weeds and soilborne pathogens. Fields are then bedded in a manner to help conserve and optimize soil moisture over the winter.

Onions are direct seeded with precision planters. Most growers utilize seed that has been treated with mixtures of fungicides (to protect against damping-off diseases) and insecticides (to protect against soil insects such as onion maggot and wireworm). Onions are grown in double rows, with rows spaced about 3 inches apart. A few growers plant onion transplants in the early spring for early harvest in July.

Transplant production is tightly regulated to prevent the introduction of white rot into the valley. Oregon and Idaho regulations governing the use of transplants differ, with Idaho regulations being more restrictive than those of Oregon. Idaho allows only locally grown transplants (effectively eliminating transplants). Oregon allows transplants from only one place: Maricopa County, Arizona.

Onions are irrigated by either furrow irrigation or drip irrigation, with drip irrigation becoming the predominant system. Subsurface drip irrigation tape is laid at planting, with tape set 2 to 4 inches deep. Two double rows are serviced by one furrow or drip tape. Growers continue to adopt soil moisture monitoring to improve irrigation. Irrigation needs vary depending on weather conditions, but drip irrigation requires approximately 50 percent of the water needed for furrow irrigation. A soil water tension (SWT) threshold of 20 centibars is recommended for triggering irrigation.

After germination, plants grow vegetatively until bulb initiation. Spring-seeded onions grown in the Treasure Valley are long-day onions, which means that bulbing is triggered by long day length at the summer solstice. The rate of bulb growth is contingent on temperature as well as plant health. The bulb is formed from the expansion of modified leaf structures at the base of the plant known as scales.

Bulbs reach physiological maturity when the neck softens and the top (the leaves) falls over. When approximately 50 percent of the onion tops in a field have fallen over, the onions are ready for lifting, which is the process of undercutting the root system to promote curing of the bulbs. Bulbs will remain in the field for an additional seven to 21 days to finish the curing process. Curing ensures that the neck and outer wrapper scales are appropriately dry for proper storage quality.

The Treasure Valley is the only storage onion region in the United States that is governed by a federal marketing order (No. 958). The marketing order is designed to ensure crop quality. Onions are inspected daily by the Federal-State Inspection Service to certify that they meet grade, size, pack, and maturity standards before shipment. The marketing order also authorizes collection of a self-imposed assessment on onion shipments to support promotion and research activities for the benefit of the industry.

Approximately 75 percent of onions grown in this region are grown for the fresh market, with approximately 25 percent going to processing. Most of the crop is sold domestically, with a small percentage (less than 5 percent) being exported to Canada and Mexico.

# IPM overview in onion production

Onions have been produced commercially in the Treasure Valley for 100 years. Initially, the most important pests were the onion maggot (*Delia antiqua*) and seedcorn maggot (*D. platura*), which could devastate onion crops by killing seedling plants. There were few management options until the late 1950s, when growers began developing areawide integrated pest management (IPM) practices. The elimination of breeding sites for the flies through the disposal of cull onions has been one of the most important practices for maggot control (control order implemented through the Idaho Administrative Procedures Act 02.06.17 and Oregon Administrative Rule 603-052-0360). Maggot outbreaks have also been reduced by crop rotation and control of volunteer onions. Sporadic outbreaks of maggots may still occur, so growers also use insecticide-treated seeds as prophylactic treatments to reduce the risk of maggot outbreaks and to minimize damage from other soil-dwelling pests, such as wireworms.

As the threat posed by maggots has receded, onion thrips (*Thrips tabaci*) have emerged as the most important arthropod pest in the Treasure Valley. Feeding by thrips reduces the photosynthetic capacity of plants, which leads to reduced bulb size and quality. The introduction of synthetic pyrethroids in the 1970s gave growers an inexpensive option for managing thrips populations, with as few as two applications being sufficient for a season. The emergence of thrips-transmitted iris yellow spot virus in the late 1990s and early 2000s disrupted the ability to manage thrips with limited insecticidal sprays.

As damage from iris yellow spot virus escalated, growers increased insecticide applications in an effort to manage thrips. Because growers continued to rely heavily on pyrethroids, especially lambda-cyhalothrin (Warrior), thrips populations rapidly developed resistance. These problems with resistance have led to significant research on insecticide rotation programs for season-long thrips management and adoption of those programs by growers. Additionally, introduction of modern insecticide chemistries targeting onion thrips has expanded potential chemistry rotations, while reducing impacts on nontarget beneficial insects. The value of insecticide rotations has been shown in recent monitoring programs, which demonstrate that thrips populations across the Treasure Valley remain susceptible to chemistries that have been recently deployed against them.

Insecticides remain the predominant management tactic for thrips and iris yellow spot virus. Growers are also adopting cultivars that are less susceptible to the virus and onion thrips, allowing in some cases for modest reductions in applied active ingredients in a season-long program while maintaining yields and productivity in parts of the Valley heavily impacted by this pest complex. Isolating fields with later-maturing cultivars from seed and overwintering crops as much as possible has also improved outcomes related to thrips and iris yellow spot virus. Drip irrigation has also been instrumental in reducing the expression of injury from the virus and other diseases. Insect counts and action thresholds are commonly used throughout the area when making pesticide applications.

IPM tactics for managing soilborne diseases remain limited. Some cultivars have a degree of tolerance to certain diseases (e.g., pink root), although true resistance has not been identified. Crop rotation can help reduce disease pressure, but most pathogens are highly persistent in the soil and reemerge when fields are replanted to onion. Consequently, growers still rely on soil fumigation and other pesticides to manage soilborne diseases.

The geographical location and crop production practices in the Treasure Valley provide substantial weed challenges to growers. Because of their sparse foliage canopy and slow growth, onions are poor competitors, which allows weeds to flourish. Consequently,it is critical for crop success. Weed management in onions requires a systems approach that combines control tactics applied during rotational crops with in-season control tactics. Onions are susceptible to losses from numerous grasses and broadleaf weeds, but the most problematic weed continues to be yellow nutsedge (*Cyperus esculentus*), a widely recognized problem weed that favors the same wet soil conditions that allow onion bulb development. Growers employ an integrated approach to manage this and other weeds, including chemical controls, mechanical controls (cultivation and hand weeding), and cultural controls (crop rotation).

Until recently, furrow irrigation has been the main form of irrigation for onion production in the Valley. Weed management in furrow-irrigated, direct-seeded onion differs from weed control in rainfed or overhead irrigation production systems, as certain soil-applied herbicides cannot be used effectively in the Treasure Valley without activation from rainfall or overhead irrigation. Also, the free flow of water from furrow irrigation has been a factor in the buildup of heavy infestations of yellow nutsedge.

The adoption of drip irrigation has improved irrigation efficiency and nitrogen fertilizer use efficiency. The improvements in nitrogen fertilizer and irrigation efficiency on onion and other associated crops have contributed to a decline in groundwater nitrate contamination. Drip irrigation has allowed delivery of herbicides through drip systems. Application of certain herbicide products through drip systems can help to better control yellow nutsedge in direct-seeded onion. However, newly emerged onion plants are very sensitive to herbicides with proven effectiveness on yellow nutsedge, which makes chemical control of this weed challenging. If new methods for controlling yellow nutsedge are not developed, growers risk onion yield reductions that can exceed 40 percent in heavily infested fields.

The continued reliance on older herbicide modes of action has led to concerns with managing herbicide resistance. Resistance has been identified in certain weeds in the Treasure Valley, such as glyphosate-resistant kochia (*Bassia scoparia*).

Herbicide applications are timed based on crop emergence and scouting for plant size (crop injury is reduced after plants reach the two-true-leaf stage), which triggers application of herbicides as well as decisions about the type of herbicide used (mode of action, etc.) and rate of application. If plants are small, herbicides may be delayed, or rates can be reduced to compensate for small plants.

Growers historically used dimethyl 2,3,5,6-tetrachlorobenzene-1,4-dicarboxylate (DCPA, Dacthal) to control weeds in onion. The use of DCPA led to groundwater contamination. This problem has been solved by the adoption of new application methods and irrigation practices to reduce runoff and by use of alternative herbicides that break down into innocuous compounds.

# IPM critical needs

The following list of broad IPM needs was compiled from a consultation meeting in November 2016 with Treasure Valley onion industry representatives and from the IPMSP work group meeting in February 2017. Meeting participants were asked to summarize needs related to each of the following headings.

## Decision and knowledge support

- Develop a pest management risk index to estimate or minimize potential for crop damage from pests.
- Increase understanding of pesticide impacts, both positive (efficacy) and negative (secondary pest outbreaks, resistance), on pest management.
- Develop improved application technology for in-field pesticide treatments to improve efficacy and minimize drift and runoff.
- Better understand the potential impact of climate change on pests and pest management, particularly thrips.
- Increase funding for agricultural Extension, education programs and applied research.
- Continue development and expansion of pest- and disease-forecasting models and increase awareness and use of these models among growers.
- Increase knowledge and understanding of pesticide efficacy.
- Improve awareness of the genetic resistance and tolerance to major onion pests available in commercial onion cultivars.
- Increase knowledge of best agronomic practices with newer onion cultivars to maximize their performance in yield, diseases and quality.

## IPM education

- Educate growers on economic threshold levels for major onion pests.
- Educate local, state and federal representatives, politicians and regulators about the pest-management practices and needs of the Treasure Valley onion industry.
- Increase patent lengths to increase the incentive for manufacturers to manage active ingredients.
- Develop a program for areawide sharing of information from crop scouting.
- Increase resistance-management education for growers.
- Educate growers who may not be aware of current IPM research and education.
- Increase understanding of the impacts of pesticide applications in one crop on resistance in other crops.

## Reduced reliance on agrochemicals

- Identify natural and lower-risk products that reduce pest development and fecundity.
- Develop more pest-resistant varieties.
- Identify trap crops for thrips.
- Increase research and education on plant-health promoters.
- Improve application techniques and timing to increase application efficacy.

- Develop genetically enhanced plants for pest resistance and plant health.
- Develop natural products that induce plant resistance to thrips.
- Increase education regarding the appropriate use of adjuvants to improve pesticide efficacy.
- Educate growers on proper identification and understanding of beneficial insects in onion fields.
- Increase research and education on cover crop benefits.

## Whole-farm and areawide management

- Increase research and education on the use of crop rotation, including biofumigant crops that complement the crop and reduce pest and pathogen pressure.
- Increase research on the relationship between field size, crop rotation and pathogen loads.
- Develop a program for areawide management of herbicide-resistant weeds.
- Reduce the regulatory paperwork burden on farmers.
- Develop better communication between the onion seed industry and the commercial onion bulb industry; a mandated system of mapping seed production fields would be ideal.
- Encourage more "hands-on" management.
- Develop programs for community or neighborhood cooperation on pest-management issues.
- Increase education on the use of borders of banker plants to enhance natural enemy populations within onion fields and other outside-the-box thinking.

## Pollinator protection

- Improve coordination between local beekeepers and the onion grower associations to increase mutual awareness of adjacent bee presence, spray timings and products used.
- Increase labeling of hives with name and contact information.
- Develop a Treasure Valley Onion Growers Managed Pollinator Protection Plan to include hive labeling, communication system and flags and markers.

## Beneficial and natural enemy protection

- Increase research on how to enhance the abundance of natural enemies in relation to thrips populations, including the timing of flowering of beneficial insectary plants and insect presence.
- Develop analysis of the economics and efficacy of natural enemies in onion production.
- Increase research on insecticide resistance in natural enemy predator populations.

## Human health and worker protection

- Develop effective alternatives to soil fumigation for farmers to use within fumigation buffer zones adjacent to schools and residential property.
- Increase both Extension educator and grower understanding of safety and worker protection standards, including outreach on new standards.
- Increase and improve training for farmworkers, especially migrant workers.

- Clarify the responsibility for carrying out sufficient worker safety trainings: Does this responsibility lie with growers, state regulatory agencies (e.g., state departments of agriculture or health and safety agencies), universities, farmworkers or labor contractors?

## Soil health

- Develop effective control programs for pink root and yellow nutsedge, including identification of effective alternatives to soil fumigation.
- Continue research on cover crops.
- Increase research on the potential for soil solarization with reliable, biodegradable mulch.
- Increase research on the potential for mycorrhizae and other bacteria and fungi, plus additives, to suppress pink root and improve plant health.

# List of major onion pests

(listed alphabetically)

## Insects

Bulb mites (*Rhizoglyphus* spp.)
Cutworms (*Agrotis ipsilon*, *Peridroma saucia*)
Leafminer (*Liriomyza trifolii*)
Onion maggot and seedcorn maggot (*Delia antiqua* and *Delia platura*)
Onion thrips (*Thrips tabaci*)
Spider mite (*Tetranychus urticae*)
Wireworms (*Limonius* spp.)
Nematodes
Root-knot nematodes (*Meloidogyne* spp.)
Root-lesion nematodes (*Pratylenchus* spp.)
Stubby-root nematodes (*Paratrichodorus* spp. and *Trichodorus* spp.)

## Diseases

Bacterial leaf blight and bulb rot (*Pantoea agglomerans*, *Pseudomonas* spp., *Burkholderia* spp., *Dickeya* spp., *Enterobacter* spp., *Pectobacterium* spp., *Xanthomonas* spp.)
Black mold (*Aspergillus niger*)
Blue mold (*Penicillium* spp.)
Botrytis leaf blight (*Botrytis squamosa*)
Botrytis neck rot (*Botrytis allii*, *Botrytis aclada*)
Damping-off (*Pythium* spp., *Rhizoctonia solani*)
Downy mildew (*Peronospora destructor*)
Fusarium basal rot/plate rot (*Fusarium oxysporum f. sp. cepae*)
Fusarium bulb rot (*Fusarium proliferatum*)
Iris yellow spot (iris yellow spot virus)
Pink root (*Setophoma [Phoma] terrestris*)
Purple blotch (*Alternaria porri*)
Stemphylium leaf blight (*Stemphylium vesicarium*)

## Weeds

Barnyardgrass (watergrass) (*Echinochloa crus-galli*)
Canada thistle (*Cirsium arvense*)
Cocklebur (*Xanthium strumarium*)
Common lambsquarters (*Chenopodium album*)
Common purslane (*Portulaca oleracea*)
Dodder (*Cuscuta* spp.)
Field bindweed (*Convolvulus arvensis*)
Kochia (*Bassia scoparia*)
Perennial peppergrass (*Lepidium latifolium*)
Puncturevine (*Tribulus terrestris*)
Redroot pigweed (*Amaranthus retroflexus*)
Roundup-ready corn (*Zea mays*)
Russian thistle (*Salsola iberica*)
Scouring rush (field edges) (*Equisetum* spp.)
Sunflower (*Helianthus annuus*)
Volunteer potato (*Solanum tuberosum*)
Wild oat (*Avena fatua*)
Yellow nutsedge (*Cyperus esculentus*)
Other grasses and broadleaves

# Onion pest management timing by crop stage

## Field preparation to preplant

Onion maggot, wireworms, bulb mites, nematodes
Black mold, Fusarium, pink root
Weeds (yellow nutsedge is primary concern; other broadleaves and grasses)

## Planting to emergence

Thrips (on volunteer onions and other alternate hosts), onion maggot, bulb mites, nematodes
Pink root, iris yellow spot virus, Pythium seed rot and damping-off
Broadleaf and grass weeds

## Vegetative growth

Thrips, spider mite, cutworms, onion maggot
Black mold, *Botrytis* leaf blight and neck rot, downy mildew, iris yellow spot virus, purple blotch
Broadleaf and grass weeds

## Lifting, harvest, storage

*Botrytis*, black mold, Fusarium

# Major onion pest descriptions

## Insects and nematodes

### Bulb mites (*Rhyzoglyphus* spp.)

For pest description information, see:
https://pnwhandbooks.org/insect/vegetable/vegetable-pests/hosts-pests/onion-bulb-mite

Bulb mites can reduce plant stands, stunt plant growth, and promote rot of bulbs in storage. On seeded onions, they can cut off the radicle before the plant becomes established. Later-season injury is caused by bulb mites penetrating the outer layer of bulb tissue and allowing rot organisms to gain entry. This pest is most damaging when plant growth is slowed by mild, wet weather and in fields with high amounts of plant residue.

### Cutworms

Black cutworm (*Agrotis ipsilon*)

Variegated cutworm (*Peridroma saucia*)

For pest description information, see: https://pnwhandbooks.org/insect/vegetable/vegetable-pests/hosts-pests/onion-armyworm-cutworm

Cutworms are occasional, sporadic pests of onion. Early season cutworm infestations can reduce plant stands. Caterpillars are difficult to detect because they hide below the soil surface during the day. They emerge at night to feed at the base of plants and can completely destroy seedlings.

### Leafminer (*Liriomyza trifolii*)

For pest description information, see: https://pnwhandbooks.org/insect/vegetable/vegetable-pests/hosts-pests/onion-leafminer

Leafminer maggots feed within onion leaves. Excessive mining reduces photosynthetic capacity and provides access for disease organisms. Although large populations may occur late in the season, leafminer populations are generally held in check by parasites and by certain insecticides targeting thrips. Insecticides, such as pyrethroids and carbamates, that eliminate parasites flare leafminer populations.

### Onion maggot (*Delia antiqua*) and seedcorn maggot (*D. platura*)

For pest description information, see: https://pnwhandbooks.org/insect/vegetable/vegetable-pests/hosts-pests/onion-onion-maggot-seedcorn-maggot

Onion maggot larvae attack germinating seedlings, feeding on the developing roots and epicotyl, which leads to stand loss. Later generations feed on the expanding bulbs. This bulb damage results in increased rot in bulbs held in storage. An areawide control order for the disposal of cull onions is in place to reduce breeding sites for these flies.

### Spider mite (*Tetranychus urticae*)

For pest description information, see: https://pnwhandbooks.org/insect/vegetable/vegetable-pests/common-vegetable/vegetable-crop-spider-mite

Spider mites can be late-season pests of onions as they disperse from other crops. Spider mite feeding causes damage similar to thrips feeding. Spider mite feeding reduces photosynthetic ability of the plant and may lead to premature senescence of the plant.

### Thrips

Onion thrips (*Thrips tabaci*)

Western flower thrips (*Frankliniella occidentalis*)

For pest description information, see: https://pnwhandbooks.org/insect/vegetable/vegetable-pests/hosts-pests/onion-thrips

Thrips are a major onion pest. Populations in the Treasure Valley are predominantly composed of onion thrips. They colonize bulb crop fields by early May, but populations tend to peak in late June and July. Thrips infestations can reduce onion yield by 20 percent or more. Onion thrips are also a major concern because they vector iris yellow spot virus. Although thrips feeding during the early bulbing stage is the most damaging to yields, thrips must be controlled before onions reach this stage. Otherwise iris yellow spot virus can be transmitted early in the onion production cycle and thrips populations can exceed levels that can be controlled adequately. Onion seed production in the Treasure Valley is considered to be a green bridge source for thrips infestation, as thrips are not actively managed in seed production once plants flower and bees are introduced into fields.

### Wireworms (*Limonius* spp.)

For pest description information, see: https://pnwhandbooks.org/insect/vegetable/vegetable-pests/hosts-pests/onion-wireworm

Wireworms are sporadic pests, especially of seedling onions. Wireworms move through the soil, where they feed on roots and emerging plants. They tend to move lower in the soil profile as temperatures increase.

### Nematodes

Root-knot nematodes (*Meloidogyne* spp.)

Root-lesion nematodes (*Pratylenchus* spp.)

Stubby-root nematodes (*Paratrichodorus* spp. and *Trichodorus* spp.)

For pest description information, see: http://www.cals.uidaho.edu/edComm/pdf/BUL/BUL909.pdf

Nematodes are present throughout the Treasure Valley and are often controlled with fumigation efforts targeted at other major pests. All plant-parasitic nematodes have a stylet, a needlelike structure that acts as a syringe to penetrate plant cells and take up nutrients. Feeding by nematodes can reduce onion plant vigor and induce lesions (areas of diseased tissue), rot, deformation, or galls (localized growth or swelling of plant tissue). Bulb yield can be reduced by as much as 70 percent.

Root-knot and stubby-root nematodes have wide host ranges, so crop rotation is of limited utility for their management. Preventive preplant soil fumigation (during the preceding fall) is used to suppress nematode populations.

## Diseases and pathogens

### Bacterial leaf blight and bulb rot (*Pantoea agglomerans*, *Pseudomonas* spp., *Burkholderia* spp., *Dickeya* spp., *Enterobacter* spp., *Pectobacterium* spp., *Xanthomonas* spp.)

For disease descriptions, see: https://pnwhandbooks.org/plantdisease/host-disease/onion-allium-cepa-bulb-rots

A range of bacteria is known to cause necrosis of onion foliage and bulb rot. Symptoms of bacterial diseases affecting foliage include necrotic lesions that lead to the collapse of leaves. Generally, some or all scales of infected bulbs break down in watery rots. Most infections occur through wounds in plant tissue. Lengthy crop rotations, allowing bulbs to reach full maturity and allowing bulbs to cure completely in the field can help reduce the incidence of bacterial diseases.

### Black mold (*Aspergillus niger*)

For disease description, see: https://pnwhandbooks.org/plantdisease/host-disease/onion-allium-cepa-black-mold

This disease attacks onions in storage and transit. It can do a great deal of damage in storage if bulbs are held at high temperatures for long periods (such as high-temperature drying in storage for more than two or three days).

### *Botrytis* leaf blight (*Botrytis squamosa*)

For disease description, see: https://pnwhandbooks.org/plantdisease/host-disease/onion-allium-cepa-botrytis-leaf-blight

This fungus primarily attacks the leaves. Initial lesions are small white spots surrounded by a greenish halo. As lesions expand, leaf tips die back. Under severe pressure, entire leaves die. Bulbs from infected plants are small because of reduced photosynthetic capacity from leaf loss.

### *Botrytis* neck rot (*Botrytis allii* and *B. aclada*)

For disease description, see: https://pnwhandbooks.org/plantdisease/host-disease/onion-allium-cepa-neck-rot

Although infection occurs in the field, this disease becomes apparent after harvest while bulbs are in transit or storage. At first, soft neck tissue looks water soaked, and a yellow discoloration moves down the neck into the scales. Bulbs break down to a soft mass. A gray mold develops between the onion scales, later producing small to large black bodies (sclerotia), which develop as a solid layer around the neck. Artificial curing by heat treatment can help limit the spread of neck rot in storage. Heat treatments must be done carefully to minimize development of black mold.

### Damping-off

See Pythium seed rot and damping-off and Rhizoctonia seed rot and seedling diseases.

### Downy mildew (*Peronospora destructor*)

For disease description, see: https://pnwhandbooks.org/plantdisease/host-disease/onion-allium-cepa-downy-mildew

This is an occasional pest in Treasure Valley onions. Plants may be dwarfed, distorted and pale green if they are systemically infected. Plants often are not killed, but bulb quality is poor and often spongy.

Fusarium basal rot and Fusarium plate rot (*Fusarium oxysporum f. sp. cepae*)

For disease description, see: https://pnwhandbooks.org/plantdisease/host-disease/onion-allium-cepa-fusarium-basal-rot

Infected plants exhibit weak growth and may wilt. Yellow flag leaves may become visible prior to bulbing as basal plates are colonized and vascular tissue becomes plugged or dysfunctional. Rot and discoloration usually affect the entire basal plate and up into the bulb scales; affected tissue appears brown, macerated and watery when bulbs are cut open. Basal plates may appear corky and disintegrate upon handling. Bulbs may appear normal at harvest, but rot may progress in storage.

### Fusarium bulb rot (*Fusarium proliferatum*)

For disease description, see: https://pnwhandbooks.org/plantdisease/host-disease/onion-allium-cepa-fusarium-bulb-rot

*Fusarium proliferatum* is an emerging pathogen in the Treasure Valley that causes internal bulb rots. Disease occurrence is related to the occurrence of incomplete and internal dry scale, a result of physiological stress that creates opportunities for secondary pathogens such as *F. proliferatum* to colonize bulbs. Infected bulbs may appear healthy externally, with infections discovered only when bulbs are cut for inspection.

### Iris yellow spot (Iris yellow spot virus)

For disease description, see: https://pnwhandbooks.org/plantdisease/host-disease/onion-allium-cepa-iris-yellow-spot

Iris yellow spot virus is relatively new to onion production in the Pacific Northwest, first spotted on onion seed crops in the Treasure Valley around 1989. Examination of weeds in the Treasure Valley has detected iris yellow spot virus-infected redroot pigweed (*Amaranthus retroflexus*), puncturevine (*Tribulus terrestris*), kochia (*Bassia scoparia*), prickly lettuce (*Lactuca serriola*), and common lambsquarters (*Chenopodium album*). This virus is transmitted by onion thrips (*Thrips tabaci*) but has not been shown to be transmitted by other thrips species in the Treasure Valley, such as the western flower thrips (*Frankliniella occidentalis*). Transplants imported into the Treasure Valley may be infected with iris yellow spot virus as well as infested with high populations of onion thrips. Studies have not shown this virus to be transmitted through onion seed.

Virus lesions begin to appear in bulb fields approximately two weeks after adult thrips begin to colonize onion fields. Bulbs of severely infected plants may not store well because of poor, incomplete neck fall (tops down) and secondary pathogen infections. Iris yellow spot virus does not move systemically within onion plants, so control of the onion thrips vector can reduce disease severity.

### Pink root (*Setophoma terrestris* [formerly *Phoma terrestris* and *Pyrenochaeta terrestris*])

For disease description, see: https://pnwhandbooks.org/plantdisease/host-disease/onion-allium-cepa-pink-root

Infected roots turn yellow, then pinkish, then bright pink to red and finally to dark purple as they dry and disintegrate. New roots produced thereafter become infected and also die. Seedlings may die. Otherwise, bulbs lack normal development, are reduced in size and vigor, and have stunted tops. Disease development accelerates in hot weather. Soil fumigation may help reduce disease severity. Certain cultivars are more tolerant than others, although none is completely resistant. In-season application of the fungicide penthiopyrad may improve pink root management.

### Purple blotch (*Alternaria porri*)

For disease description, see: https://pnwhandbooks.org/plantdisease/host-disease/onion-allium-cepa-purple-blotch

This is an occasional pest in Treasure Valley onions. The fungus overwinters in infected bulbs and plant debris. It may also be seedborne. Infected foliage initially develops small, water-soaked lesions. Lesions enlarge and turn brown to purple. Bulbs may decay during and after harvest.

### Pythium seed rot and damping-off (*Pythium* spp.)

For disease description, see: http://extension.colostate.edu/topic-areas/agriculture/soil-borne-diseases-of-onion-2-940/

*Pythium* spp. is one of the causal agents of damping-off in onions. Water-soaked lesions develop along the base of infected plants, and a watery rot occurs on roots before roots turn black as they decay. The fungus can also infect seeds before germination, causing decay. Surviving infected plants are stunted and have yellowed, wilting leaves.

### Rhizoctonia seed rot and seedling diseases; damping-off (*Rhizoctonia solani* and other spp.)

For disease description, see: http://apps.planalytics.com/aginsights/images/pipe/2011_WSU_Onion_Field_Day_report_Rhizoc_Seedling_Blight_2011-08-05.pdf

Rhizoctonia is another causal agent of damping-off in onions, which leads to patches of stunted plants in onion bulb crops, especially in fields with significant amounts of cereal crop residues. These include fields planted with cereal cover crops. Infected plants show symptoms similar to those infected with Pythium. In addition, root tips of Rhizoctonia-infected plants slough off, resulting in "spear-tipping." Preemergence infection of onion seedlings can result in seedling damping-off. The most common results of postemergence infection of onion seedlings are stunting and plant death.

### Stemphylium leaf blight (*Stemphylium vesicarium*)

For disease description, see: http://www.hort.cornell.edu/expo/proceedings/2014/Onions/Stemphylium%20Tesfaendrias.pdf

Stemphylium leaf blight causes purple lesions on foliage. This fungus has frequently been recovered from dead and dying onion foliage in the Treasure Valley. This disease frequently starts as straw-colored tip dieback or small chlorotic lesions on foliage. Infections then progress to black sporulating sections of necrotic foliage. Yield and quality may be reduced by premature defoliation. Because of similarity in foliar symptoms, Stemphylium leaf blight may be misidentified as purple blotch.

## Weeds

Weeds are a major concern, as onions have sparse vegetation, are slow-growing, and do not compete well with weeds. A weedy field reduces plant vigor, bulb size, and, subsequently, yields. Weed control prior to and at planting, as well as during vegetative growth, is critical for the crop. Hard-to-control weeds such as yellow nutsedge, field bindweed, common mallow, and kochia are particularly problematic. Specific weeds and management issues are discussed in more detail in the following sections.

A wide range of broadleaf and grass weeds are found in the onion-growing areas of the Treasure Valley, including:

Barnyardgrass (watergrass) (*Echinochloa crus-galli*)
Canada thistle (*Cirsium arvense*)
Cocklebur (*Xanthium strumarium*)
Common lambsquarters (*Chenopodium album*)
Common purslane (*Portulaca oleracea*)
Dodder (*Cuscuta* spp.)
Field bindweed (*Convolvulus arvensis*)
Kochia (*Bassia scoparia*)
Perennial peppergrass (*Lepidium latifolium*)
Puncturevine (*Tribulus terrestris*)
Redroot pigweed (*Amaranthus retroflexus*)
Roundup-ready corn (*Zea mays*)
Russian thistle (*Salsola iberica*)
Scouring rush (field edges) (*Equisetum* spp.)
Sunflower (*Helianthus annuus*)
Volunteer potato (*Solanum tuberosum*)
Wild oat (*Avena fatua*)
Yellow nutsedge (*Cyperus esculentus*)

## Other grasses and broadleaves

For descriptions of specific weeds and management, see: https://pnwhandbooks.org/weed/horticultural/vegetable/onions

# Pest management by crop stage

# Field preparation to preplant (September–March)

Field preparation, including plowing, disking and application of selected herbicides (normally Dual Magnum or EPTAM), typically is accomplished in the fall prior to planting, although it may be done in early spring of the planting year.

Pest management priorities during preplant, which is closer to planting time, include onion maggot, wireworms, bulb mites, nematodes, black mold, Fusarium root rot and basal rot, Rhizoctonia root rot, pink root, and weeds (yellow nutsedge, broadleaves, grasses). Cutworms and white grubs may be incidental pests. Application of glyphosate (during spring) prior to onion emergence is critical for successful management of weeds that emerge ahead of onion.

## Field activities and pest management decisions that occur during field preparation through preplant

Sulfuric acid application to keep soil crust from forming

Cover crop planting

Soil tillage

Cover crop removal (herbicide or tillage)

Soil sampling for nutrients or nematodes

Scouting for weeds and insects

Bed preparation and shaping

Soil fumigation

Fertilizing

Preplant herbicide application

| PAMS[1] practice | Field preparation to preplant pest management activities | Target pest(s) |
|---|---|---|
| Prevention | Local control order requires use of clean, pest- and disease-free transplants. | White rot, thrips |
| | Practice field sanitation to reduce pest reservoirs (cull disposal, volunteers); local control orders are in place for cull removal to control onion maggot. | Thrips, maggots |
| | Clean equipment between fields to avoid dispersing contaminated soil, tubers, or seed to uninfested fields. | Pink root, yellow nutsedge |
| | Avoid early season cover crops (used to prevent crop injury) that are hosts for nematodes and Rhizoctonia, such as cereal crops, which can be a green bridge host. | Nematodes |
| | Minimize plant debris. | Maggots, bulb mites |
| Avoidance | When selecting varieties, place the most tolerant cultivars in “hotspot” fields. | Pink root, IYSV |
| | For red onion plantings, favor field locations that have had longer rotations or virgin ground. | IYSV, pink root |
| | Avoid planting in fields with heavy infestations. | Weeds (primarily yellow nutsedge) |
| | Maximize distance from neighboring onion crops and onion seed crops and the previous season’s fields. | Thrips/IYSV |
| | After soil testing, avoid fields with significant levels of nematodes. | Nematodes |
| | Design row orientation and spacing to maximize air movement to reduce leaf wetness (e.g., larger spacing for inner rows, less spacing for outer rows). Population size can impact bacterial diseases and Botrytis spp. | Botrytis spp., bacterial diseases |
| | Plow yellow nutsedge-free fields before plowing infested fields. | Weeds (primarily yellow nutsedge) |
| | Follow proper crop rotation practices (avoid short rotations) to reduce weed seed buildup, manage perennial weeds, and enable herbicide rotation. | Weeds |
| | Practice optimal nitrogen fertilization for increased plant health, which reduces pest pressure. | Thrips, Botrytis neck rot |
| | Avoid overhead irrigation. | Bacterial diseases |
| | Limit irrigation to avoid vigorous growth. | Bacterial rot |
| Monitoring | Sample for nematodes before making fumigation and planting decisions. | Nematodes |
| | Scout for weeds and insects. | Primarily yellow nutsedge, thrips |
| | Manage perennial weeds prior to onion emergence. | Canada thistle, field bindweed |
| | Soil test for soil fertility to optimize plant health. | |
| Suppression | Use flaming for weed control along field edges and on smaller-scale farms. | Kochia, scouring rush |
| | Cultivate. | Winter annual weeds |
| | Use deep plowing and crop rotation to reduce sclerotia in the root zone. | Botrytis spp. |
| | Rotate chemistries to prevent pesticide resistance. | Insects and weeds |

[1] See Using PAMS Terminolpogy, page 54

| | | |
|---|---|---|
| Suppression | At-planting insecticide applications: Use of chlorpyrifos (Lorsban) is decreasing with the increased use of seed treatments. | Onion maggot, seedcorn maggot |
| | Field preparation herbicide applications: 2,4-D, Dimethenamid-p (Outlook), EPTC (Eptam), Glyphosate (Roundup), S-metolachlor (Dual Magnum). | Field bindweed, yellow nutsedge |
| | Fungicide seed treatments: Farmore (azoxystrobin [Dynasty], fludioxonil [Maxim 4FS], Mefenoxam [Apron XL]), Metalaxyl (Allegiance), Pyraclostrobin + boscalid (Coronet), Thiram (Thiram). | Botrytis spp., black mold, damping-off diseases (Fusarium spp., Pythium spp., Rhizoctonia spp.) |
| | Insecticide seed treatments: Clothianidin (Sepresto), Thiamethoxam (Cruiser) + spinosad (Regard), which are components of Farmore FI500 seed treatments. Both are substitutes for chlorpyrifos (Lorsban) | Onion maggot, seedcorn maggot, wireworms |
| | Preemergence herbicides (prior to onion and weed emergence): Bensulide (Prefar) not often used, Ethofumesate (Nortron). | Broadleaf and grassy weeds |
| | Delayed or late-preemergence herbicides (applied prior to onion emergence): Glyphosate (Roundup), Pendimethalin (Prowl H20). | Broadleaf and grassy weeds |
| | Soil fumigation (before beds are created): 1,3-dichloropropene, Chloropicrin, Metam potassium (K-pam), Metam sodium (Vapam). | Pink root, weeds, nematodes |

[1] See Using PAMS Terminolpogy, page 54

## Critical needs during field preparation to preplant

### Research topics

- *Fusarium proliferatum* (bulb rot), specifically alternate hosts, including corn as a prior or neighboring crop.
- Economic thresholds for major onion pests.
- Extent of presence and damage of various *Rhizoctonia* species.
- Bacterial rots and soil survival (understanding alternate hosts and survival in soil throughout the year will help with prediction and management).
- Pathogen populations and utilization of soil tests for critical numbers to determine thresholds for these pathogens.
- Alternative effective soil-applied chemistries to use as seed treatments, including alternatives to chlorpyrifos (Lorsban)
- Management practices based on areawide or neighboring field cooperation for key pest issues, particularly thrips and iris yellow spot virus.
- Whole-farm and multiple-farm planning and management practices.
- Use and efficacy of biofumigants for nematode suppression.
- Effective controls for pink root, including alternatives to fumigation.
- A program for assigning resistance screening scores to onion cultivars for certain pests (e.g., pink root).
- Effective preemergence products for weed control.
- Drip-delivered products and technologies to provide needed suppression where plants are growing, specifically for pink root and weed control.

### Regulatory actions

- Adjust product labels to allow use of preemergence herbicides in fall applications.
- Retain labels for insecticide seed treatment combinations, such as imidacloprid + clothianidin (Sepresto) and thiamethoxam + spinosad (Farmore FI500). These products are current substitutes for chlorpyrifos.

Photo: © Oregon State University

## Education

- Educate custom applicators on the importance of cleaning or sanitizing equipment between fields.
- Increase communication and education between landowners and growers on the importance of weed control.
- Educate and motivate seed companies to locate onion seed fields away from commercial onion production.
- Educate and communicate with seed growers on the importance of continuing with thrips control after pollination; this control can help with virus control.
- Create a “pin map” program between onion seed and onion bulb growers to document locations of seed production fields relative to onion bulb crop fields.
- Educate growers about nematodes, including the importance of testing and best management practices, to make clear that nematodes are a persistent issue.
- Increase communication for areawide management with particular attention to constraints, including uncertainties about contracts and water availability.
- Educate growers regarding the importance of preplant soil temperature monitoring to better assess planting time, crop emergence, and weed development for the timing of herbicide applications.

# Planting to crop emergence (March–May)

Most dry bulb onions are direct seeded with precision planters. Planting occurs primarily from early March through April, and the soil crust must be broken for emergence to take place. A small percentage of the crop is grown as overwinter "sweet onions" that are seeded in the fall and harvested in the late spring. Specific concerns related to overwinter production are not addressed in this strategic plan.

Depending on environmental conditions, irrigation begins once the onion seedlings have emerged. Irrigation may be necessary to assist with germination and to help with seedling emergence. (Irrigation prevents the soil from crusting and thus aids in emergence.) Transplanted onions, if used, require irrigation immediately after planting. Emergence is the point at which the flag leaf (thin, curved, cotyledonal leaf) has emerged from the soil ("loop" stage). It can take from 10 to 30 days after seeding before a seedling emerges and a flag leaf is present.

Insect management priorities in this crop stage include thrips, onion maggot, seedcorn maggot, bulb mites and nematodes. Cutworms and white grubs may be incidental pests. Disease priorities include pink root, iris yellow spot virus, damping-off (*Pythium* spp.), and *Rhizoctonia* spp. Weeds require management during this stage as well. Once onions are planted, several weeks elapse before they emerge from the ground. During this period, many weeds can emerge.

### Field activities and pest management decisions that may occur during planting through emergence

Scouting for weeds and insects

Breaking soil crust (to improve emergence and plant stand)

Cover crop or windbreak planting

Fertilizing

Preemergence and delayed preemergence herbicide applications

Planting (seeds or transplants)

Irrigation

| PAMS practice | Planting to emergence pest management activities | Target pest(s) |
|---|---|---|
| Prevention | Clean equipment to avoid movement of soilborne diseases and weeds. | Pink root, yellow nutsedge |
| Avoidance | Optimize plant population and germination to achieve some pest control; however, this is not a stand-alone practice. Uniform stands have lower thrips colonization than patchy stands. | Thrips (for avoidance of IYSV), bacterial leaf blight |
| | Manage irrigation to mitigate salt concentrations in the germination zone and improve plant health. | |
| Monitoring | Scout for weed development and onion emergence to time herbicide applications. | Grasses, broadleaves |
| Suppression | Soil insecticides (e.g., chlorpyrifos) used in place of (and sometimes in addition to) seed treatment | Maggots, wireworms, white grubs, cutworms |
| | Fungicide-coated seed:<br>▪ Farmore (azoxystrobin [Dynasty]<br>▪ fludioxonil [Maxim 4FS]<br>▪ Mefenoxam [Apron XL])<br>▪ Metalaxyl (Allegiance)<br>▪ Pyraclostrobin + boscalid (Coronet)<br>▪ Thiram (Thiram) | Damping-off diseases (Fusarium spp., Pythium spp., Rhizoctonia spp.) |
| | Soil-applied fungicides using in-furrow applications:<br>▪ Azoxystrobin (Quadris) | Damping-off diseases |
| | Soil-applied fungicides:<br>▪ Penthiopyrad (Fontelis) applied at planting or via chemigation | Pink root, Rhizoctonia spp. |
| | Herbicides applied prior to onion emergence:<br>▪ Ethofumesate (Nortron) | Weeds |
| | Late or delayed preemergence herbicides (prior to onion emergence):<br>▪ Pendimethalin (Prowl H2O)<br>Note: Special Local Needs (SLN) label in ID/OR/WA allows pendimethalin (Prowl H2O) to be applied delayed preemergence (after about 75 percent of the onions have germinated but before they emerge from the soil). Pendimethalin applied in this way is often mixed with glyphosate (Roundup). This combination controls emerged weeds prior to onion emergence and provides soil activity against weeds that will emerge later. The efficacy of pendimethalin applied this way depends on rainfall or irrigation for activation. | Weeds |
| | Broadleaf herbicides applied after onion emergence (consult the label for rate and timing relative to the crop):<br>▪ Bromoxynil (Buctril, Brox)<br>▪ Dimethenamid-p (Outlook)<br>▪ Ethofumesate (Nortron), Fluroxypyr (Starane Ultra)<br>▪ Oxyfluorfen (Goal 2XL/Goaltender)<br>▪ S-metolachlor (Dual Magnum) Pendimethalin (Prowl H2O) | |
| | Grass herbicides applied after onion emergence:<br>▪ Clethodim (Select, Select Max, Shadow)<br>▪ Sethoxydim (Poast)<br>▪ Fluazifop (Fusilade)<br>▪ Pendimethalin (Prowl H2O) | |

## Critical needs during planting to crop emergence

### Research topics

- Potential for use of sulfuric acid for crust reduction to provide secondary benefits for reducing bacterial diseases.
- Sources of bulb mite populations and the effects of crop residues on bulb mite populations.
- Alternative efficacious products for in-season bulb mite control (e.g., azadirachtin).
- Effective cultural controls for bulb mites.
- Bulb mites, specifically life cycle and potential for crop damage.

### Regulatory actions

- Pursue registrations for new products labeled for bulb mites (e.g., azadirachtin if found to be efficacious).
- Education.
- Improve access to areawide weather data and decision support tools for the onion industry.

# Vegetative growth (May–August)

After seedling emergence (flag leaf), the first true leaves are formed and the plant grows vegetatively for about five to eight weeks, producing larger plants with long, upright leaves before bulb formation begins. Timing of bulb formation varies by cultivar and also depends on day length. When the fleshy leaves at the base of the plant (scales) enlarge, the bulb begins to form. Bulb formation can take up to 10 weeks, until the bulb is large enough and mature enough for lifting and harvest.

Pest management priorities during this stage include onion maggot, thrips, spider mite, bulb mites; black mold, Botrytis leaf blight and neck rot, downy mildew, iris yellow spot virus, Stemphylium leaf blight, purple blotch, bacterial bulb rots, Fusarium leaf blight/bulb rot; and weeds, particularly yellow nutsedge, hairy nightshade, common lambsquarters, pigweeds, kochia, barnyardgrass and volunteer potatoes.

Onions have sparse vegetation and are slow growing; as such, they do not compete well with weeds. The early stages of vegetative growth are a critical time for diligent weed management. Weeds such as yellow nutsedge grow in dense patches and produce so many shoots that hand removal is impractical and ineffective. Hand weeding labor is extremely expensive and can reduce the grower's returns.

Because of the slow growth of onions, weeds can be quite large when onions finally produce two true leaves, the stage at which onions become tolerant to most herbicides used during vegetative growth. Growers constantly balance weed control efficacy with crop safety. Higher herbicide rates may be required to control the weeds that are present but may also cause greater onion injury.

### Field activities and pest management decisions that may occur during vegetative growth

Irrigation

Fertilizing

Preemergence or postemergence herbicide application

Fungicide and pesticide applications

Cultivation between the rows

Hand weeding; scouting for weeds, insects, and diseases

| PAMS practice | Vegetative growth pest management activities | Target pest(s) |
|---|---|---|
| Prevention | Manage irrigation to reduce plant stress and disease severity. | IYSV, pink root |
| | Clean equipment to avoid movement of soilborne diseases and weeds. | Pink root, yellow nutsedge |
| Avoidance | Fertilize to reduce plant stress. | IYSV, bulb rots |
| | Optimize fertilization to reduce disease risk. | Botrytis spp. |
| Monitoring | Monitor insect pests, pest damage, and beneficial insects. | Thrips, mites, wireworms, onion maggot, cutworms |
| | Monitor for disease. | Bacterial/fungal pathogens |
| | Use disease forecasting models to improve timing of fungicide/bactericide applications. | Bacterial/fungal pathogens |
| | Use areawide alerts by Extension. | Thrips/IYSV |
| Suppression | Hand weed. | Weeds |
| | Cultivate between rows. | Weeds |
| | Optimize fertilization to limit pest population growth. | Thrips |
| | Rotate insecticides to reduce development of resistance. | Thrips/IYSV |
| | Rotate fungicide chemistries to avoid resistance development. | Fungal/bacterial pathogens |
| | Apply copper bactericide to suppress bacterial diseases triggered by hail or rainstorms. | Bacterial bulb rots |
| | **Insecticides:**<br>▪ Abamectin (Agri-Mek)<br>▪ Abamectin + cyantraniliprole (Minecto Pro)<br>▪ Azadirachtin (AZA-Direct)<br>▪ Cyantraniliprole (Verimark, Exirel)<br>▪ Imidacloprid (Admire Pro) (for wireworm control via chemigation)<br>▪ M-Pede<br>▪ Methomyl (Lannate LV), Oxamyl (Vydate)<br>▪ Spinetoram (Radiant)<br>▪ Spinosad (Success)<br>▪ Spirotetramat (Movento) | Thrips/IYSV, bulb mites, wireworms, cutworms, maggots |
| | **Herbicides:**<br>▪ Bensulide (Prefar)<br>▪ Bromoxynil (Buctril)<br>▪ Clethodim (Select or Select Max)<br>▪ Dimethenamid-p (Outlook)<br>▪ Ethofumesate (Nortron)<br>▪ Fluazifop (Fusilade)<br>▪ Fluroxypyr (Starane Ultra): mostly used for kochia and volunteer potatoes; also used for bindweed suppression<br>▪ Oxyfluorfen (Goal 2XL/GoalTender)<br>▪ Pendimethalin (Prowl H2O)<br>▪ S-metalochlor (Dual Magnum)<br>▪ Sethoxydim (Poast) | Weeds |

| | | |
|---|---|---|
| | **Fungicides:**<br>▪ Azoxystrobin (Quadris)<br>▪ Chlorothalonil (Bravo Weatherstik)<br>▪ Dicloran (Botran)<br>▪ Fludioxinil + famoxadone (Tanos)<br>▪ Mancozeb (Dithane 75DF Rainshield)<br>▪ Mancozeb (Manzate)<br>▪ Mancozeb + copper = mancocide<br>▪ Pyraclastrobin (Cabrio)<br>▪ Pyraclostrobin + boscalid (Pristine)<br>▪ Copper is often used as a coformulation to avoid additional copper applications<br>▪ Penthiopyrad (fontelis): for pink root management | Botrytis leaf blight and neck rot |

## Critical needs during vegetative growth

### Research topics

- Resistance management for herbicides, fungicides and insecticides.
- Effective use of existing herbicides and other effective alternative controls, in light of the lack of new herbicide development.
- Copper resistance issues.
- Inoculation period for *Fusarium proliferatum*, including temperature relationships, alternate hosts and best timing for control.
- Mode of infection with *Fusarium prolifera*tum (e.g., does infection occur through the top or the bottom of the plant?).
- Effective late-season thrips-control tools, especially in furrow-irrigated onions, to reduce reliance on methomyl (Lannate), which is becoming less efficacious, perhaps due to overuse.
- Additional modes of action for thrips management to reduce reliance on methomyl (Lannate) and other effective, cost-effective management strategies.
- Thrips biology, life cycle, resistance, and potential for resistance.
- Areawide monitoring and management program for thrips, IYSV and plant pathogens.
- Thrips and IYSV: potential virus cures and effective alternative management strategies. (Virus pressure necessitates thrips management.)
- Secondary pests and new hosts.
- Effective yellow nutsedge management practices.
- Crop ecology approach for isolation from pest hosts.
- Variety screening trials for all major plant pests and diseases, with improved communication and harmonization of disease response and performance by variety.
- Large-scale, experimental testing of variety performance on farms and in commercial settings to include research on efficacy of variety performance when combined with use of IPM tactics.
- Presence of *Stemphylium* infections versus *Alternaria*, as well as disease cycles and etiology for both, to improve and better target disease management.
- Research on fungicide efficacy for management of *botrytis*.

### Regulatory actions

- Allow growers more options for late-season control of thrips, such as registration of Formetanate hydrochloride (Carzol) for late-season control, to reduce reliance on methomyl (Lannate).
- Adjust herbicide label language to better protect against crop injury.
- Pursue a label for use of bentazon (Basagran) for yellow nutsedge control in onions.

### Education

- Educate growers on proper diagnosis and identification of pest problems to manage rare and secondary pests and diseases.
- Educate growers on pesticide risk management.
- Continue funding for ongoing areawide alerts by Extension for thrips and IYSV.

- Continue education programs on insect- and weed-resistance management.
- Educate growers regarding research on *Fusarium proliferatum*.
- Educate growers on the use of diagnosis to manage rare diseases (downy mildew, purple blotch).
- Educate growers on research regarding secondary pests and alternate hosts.
- Educate growers on proper identification of Stemphylium and purple blotch (*Alternaria porii*), as well as disease cycles and etiology, to improve and target management tactics.

# Lifting, harvest and storage (August–September)

The process of topping, lifting and harvesting dry bulb onions begins in late summer. The sprout suppressant maleic hydrazide is used widely for onions going into long-term storage. It is applied when about 50 percent of the onion tops have fallen over but while the foliage is still green, approximately 7 to 10 days after the final irrigation. Green foliage is necessary for translocation of maleic hydrazide to the bulb.

Lifting is a cultural practice used to accelerate maturation. It helps to field-cure the onions in preparation for harvest and storage. During lifting, the bulb is undercut, typically with a machine that severs the root system below the onion bulb. Lifting takes place when about 50 percent of the tops have fallen over. Tops may be cut mechanically at the same time as lifting.

After lifting, the onions remain in the field for about 10 to 20 days until they are cured and ready for harvest.

Harvest is the removal of onions from the field once they have been lifted and field cured. However, lifting is the stage considered as “harvest” in the regulatory system and is used to determine preharvest intervals for pesticide applications.

Most dry bulb storage onions are mechanically harvested during September. Mechanical loaders pick up and load the field-cured bulbs into trucks that take them to the storage shed. (In some areas, where transplanted onions produce thin-skinned bulbs, onions are lifted mechanically but topped by hand.) Heat curing may inhibit diseases, although it can increase the risk of black mold. Onions store best under dry, cool conditions with positive air circulation.

Pest management priorities during this stage include thrips, onion maggot, bulb mites, nematodes, Botrytis leaf blight and neck rot, bacterial bulb rot, black mold, Fusarium bulb rot and basal plate rot.

### Field activities and pest management decisions that may occur during lifting, harvest and storage

Lifting (undercutting) onion bulbs

Topping bulbs (mechanical)

Windrowing bulbs

Bagging (white onions) for curing

Removing drip irrigation tape

Loading bulbs for transport to packing and storage sheds

| PAMS practice | Lifting/harvest/storage pest management activities | Target pest(s) |
|---|---|---|
| Prevention | Clean equipment to avoid movement of soilborne diseases and weeds. | Pink root, yellow nutsedge |
| Avoidance | Avoid harvesting in wet or damp conditions. | Black and blue molds, bacterial diseases |
| | Maintain low relative humidity in storage. | Diseases |
| Monitoring | Monitor and maintain appropriate environmental conditions (temperature and humidity) in storage. | Diseases |
| Suppression | Assure that necks are dried/sealed. | Botrytis neck rot |
| | Harvest under dry conditions. | Black and blue molds |
| | Heat-cure bulbs. | Botrytis spp. |
| | Control temperature and ventilation for suppression of disease development and spread and occasionally to prevent spread of thrips. | Botrytis spp., Fusarium spp., Bacterial rots |

## Critical needs during lifting, harvest and storage

### Research topics

- Early, in-season, and storage detection and monitoring of storage diseases.
- Increase research on scouting and the use of advanced technologies to support pest management decision-making (for example, drones, satellite, remote-sensing and predictive models)
- Impact of wet weather and drying time on harvest timing.
- Impacts of heat stress and water management during heat stress on storability of onions.
- Subsampling and incubation to determine pathogen presence and best timing for storage (shorter term versus longer term).
- Effective fungicides for storage rots.
- Impacts of storage humidity and temperature on onion sprouting.

### Regulatory actions

- Communicate with EPA regarding the regulatory definition of onion harvest and the impacts this has on pest management for storage rots; adjust definition of “harvest” to reflect time of onion removal from field rather than lifting to allow for later treatments to control rots in storage.
- Evaluate new Worker Protection Safety restrictions and communicate issues regarding early reentry restrictions; allow exceptions for consultants and monitoring, etc.

### Education

- Educate growers about proper disease identification (such as dry leaf versus storage rots) for early detection.

# Invasive and emerging pests

## Insects and mites

### Allium leafminer (*Phytomyza gymnostoma*)

For information: http://ento.psu.edu/extension/vegetables/pest-alert-allium-leafminer

Larvae mine down leaves and into the neck of bulbs. This pest has been detected in Pennsylvania. Prevention is possible with quarantine. Other leafminers can be controlled by generalist parasites.

**2019 update:** This pest has spread further throughout the Northeast and remains an important pest for monitoring. For pest alert information, see: https://www.oregon.gov/ODA/shared/Documents/Publications/IPPM/AlliumLeafminerPestAlert.pdf

## Diseases

### White rot

For information, see: https://www.plantmanagementnetwork.org/pub/php/review/2013/whiterot/

There is an outbreak of white rot in northern Idaho. Control orders are in place in the Idaho counties of the Treasure Valley and in Malheur County, Oregon, to reduce the likelihood of the pathogen being introduced into the Treasure Valley (see https://adminrules.idaho.gov/rules/2000/02/0607.pdf and https://secure.sos.state.or.us/oard/view.action?ruleNumber=603-052-0347).

## Weeds

Glyphosate-resistant weeds, including kochia (*Bassia [Kochia] scoparia*), common lambsquarter and Russian thistle.

Overuse and inappropriate applications (e.g., sublethal rates) of Roundup and other glyphosate products has led to selection for resistant weeds. Glyphosate-tolerant or resistant kochia is becoming more prevalent in the Treasure Valley. IPM programs for weeds are critically needed.

## Critical needs for invasive and emerging pests

### Research topics

- Monitoring the spread of herbicide-resistant weeds.
- Effective IPM practices for weed management.
- Herbicide-resistance management programs.
- Causes of incomplete scale and management tactics.
- Fungicide efficacy against *Fusarium proliferatum*.

### Regulatory actions

- Monitoring programs are needed for allium leafminer.

### Education

- Educate growers on causes and consequences of herbicide resistance.
- Educate growers on rare but potentially devastating pest issues.
- Educate growers on the need for awareness and monitoring of allium leafminer, including proper pest identification.

# References

IPM PRiME Pesticide Risk Mitigation Engine

https://ipmprime.org/pesticides/

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# Appendix

# Activity tables for Treasure Valley onions

Notes:

1. An activity may occur at any time during the designated time period but generally not continually during that time period.
2. Each "X" in the table represents one week of the month.

### Field activities (other than pest management)

| Activity | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bed preparation and shaping (fall and spring before planting) | | | XXXX | XXX | | | | | XXX | XXXX | XXXX | |
| Cover crop planting | | | | | | | | | XXXX | XXXX | | |
| Cover crop elimination | | | XXXX | XXXX | | | | | | | | |
| Planting | | | XXXX | XXX | | | | | | | | |
| Crust removal | | | XX | XXXX | X | | | | | | | |
| Soil testing for nutrients | | | XX | XXXX | XXXX | XXXX | | | XX | XXXX | XX | |
| Plant tissue (root) testing for nutrients | | | | XX | XXXX | XXXX | | | | | | |
| Fertilization | | | XXXX | XXXX | XXXX | XXXX | | | XXX | XXXX | XXXX | |
| Irrigation | | | | XX | XXXX | XXXX | XXXX | XXX | | | | |
| Lifting | | | | | | | X | XXXX | XXXX | X | | |
| Loading | | | | | | | | XXXX | XXXX | XXX | | |
| Topping | | | | | | | X | XXXX | XXXX | X | | |

### Pest management activities

| Activity | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cultivation (plowing, disking) | | | | | | | | | | XXXX | XXXX | |
| Fumigant application | | | | | | | | | | XXXX | XXXX | |
| Fungicide application (includes at planting and in season) | | | XXXX | XX | | XXX | XXXX | XXXX | X | | | |
| Hand weeding | | | | | XX | XXXX | XXXX | XX | | | | |
| Heat curing | | | | | | | | XXXX | XXXX | XXXX | | |
| Herbicide application | | | XXXX | XXXX | XXXX | XXXX | | | XXXX | XXXX | XX | |
| Insecticide application (includes at planting and in season) | | | XXXX | XXXX | XXXX | XXXX | XXXX | XXX | | | | |
| Nematicide application (not including fumigation) | | | XXXX | XXXX | X | | | | | | | |
| Nematode sampling | | | | | | | | | XX | XXXX | | |
| Scouting and monitoring | | | XXXX | XXXX | XXXX | XXXX | XXXX | XXXX | X | | | |

# Seasonal pest management for Treasure Valley onions

Notes:
X = times when pest-management strategies are applied to control these pests, not all times when pest is present.
Each X in the table represents 1 week of the month.

| **Insects and nematodes** | **Jan.** | **Feb.** | **Mar.** | **Apr.** | **May** | **June** | **July** | **Aug.** | **Sept.** | **Oct.** | **Nov.** | **Dec.** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bulb mites | | | | X | X | | | | | | | |
| Cutworms | | | | X | X | | | | | | | |
| Leafminer | | | | | | | | XXX | X | | | |
| Nematodes | | | | X | X | | | | X | XXXX | XX | |
| Onion maggot | | | XXXX | XXXX | XX | | | | | | | |
| Onion thrips | | | | | XXX | XXXX | XXXX | XXX | | | | |
| Spider mites | | | | | | XX | XXXX | XXX | | | | |
| Wireworms | | | | XXXX | X | X | | | | | | |

| **Diseases and viruses** | **Jan.** | **Feb.** | **Mar.** | **Apr.** | **May** | **June** | **July** | **Aug.** | **Sept.** | **Oct.** | **Nov.** | **Dec.** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bacterial diseases | | | | | X | X | X | X | X | X | X | X |
| Black mold | | | | | | | | | X | X | X | X |
| Botrytis leaf blight | | | | | | | X | X | X | | | |
| Botrytis neck rot | | | | | | | X | X | X | X | X | |
| Downy mildew | | | | | X | X | X | | | | | |
| Fusarium (basal rot/plate rot) | | | | | | X | X | X | X | | | |
| Iris yellow spot virus | | | | | X | X | X | X | | | | |
| Pink root | | | X | X | | | | | | | | |
| Pythium (damping-off) | | | X | X | X | | | | | | | |
| Purple blotch | | | | | X | X | X | X | | | | |
| Rhizoctonia (damping-off) | | | X | X | X | | | | | | | |
| Stemphylium leaf blight | | | | | X | X | X | X | | | | |

| **Weeds** | **Jan.** | **Feb.** | **Mar.** | **Apr.** | **May** | **June** | **July** | **Aug.** | **Sept.** | **Oct.** | **Nov.** | **Dec.** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Annual broadleaves | | | XXXX | XXXX | XXXX | XXXX | | | XXXX | XXXX | | |
| Perennial broadleaves | | | | XXXX | XXXX | XXXX | XXXX | XXXX | XXXX | XXXX | | |
| Annual grasses | | | | XXXX | XXXX | XXXX | | XXXX | XXXX | | | |
| Woody species | | | XXXX | XXXX | XXXX | XXXX | | | | | | |

# Onion pesticide risk management

The letters below represent four categories of nontarget risk potentially affected by pesticide use. If a letter is used, it indicates that mitigation is needed at commonly used application rates in order to reduce risk. Risks were calculated using the risk assessment tool IPM PRiME. This table does not substitute for any mitigations required by the product label.

**A**= Risks to aquatics: invertebrates and fish
**T**= Risks to terrestrial wildlife: birds and mammals
**P**= Risks to pollinators: risk of hive loss
**B**= Risks to bystanders: e.g., a child standing at the edge of the field

Any product in red is classified as a "highly hazardous pesticide" (HHP) by the World Health Organization and the Food and Agriculture Organization of the United Nations. These products may pose significant risks to human health or the environment, and risk reduction measures may not be effective in mitigating these risks.

| **Pesticides** | **Risks requiring mitigation** | **Preplant (Sept. – March)** | **Planting – emergence (March _ April)** | **Vegetative growth (May – August)** | **Lifting, harvest and storage (August _ Sept.)** | **Target pests** | **Comments** |
|---|---|---|---|---|---|---|---|
| **Insecticides** Products marked with ^ are go-to products; those marked with * are considered critical to the industry. | | **Number of applications per crop stage** ^ indicates critical use timing | | | | | |
| Abamectin (Agri-Mek) | A, P | | | 1–2 | | Thrips, red spider mite | Rotational partner |
| Azadirachtin (Azadirect) | | | 1 early | 2–4 May to June | | Thrips, bulb mites (not on label) | Rotational partner |
| *Bt* products | | | | | | Cutworms and other Lepidoptera | Only occasional use |
| *Chenopodium ambrosioides* extract (Requiem) | | | | | | Thrips | Limited use |
| Chlorpyrifos (Lorsban) | A ,T, P, B | | 1 | | | Maggots | Fair control |
| Cyazypyr (Exirel) | ? | | | 1–2 | | Thrips | Use currently limited by price |
| Diazinon | A, T, P, B | | 1 | | | Wireworms | |
| Dinotefuran (Scorpion) | A, P | | | 1 | | Thrips | Can be applied via drip irrigation |
| Imidacloprid (Admire) | A, P | | 1 | | | | |
| Lambda-cyhalothrin (Warrior) | A, P | | | | | Cutworms | Sometimes used, but pyrethroids flare thrips |
| Kaolin (Surround) | | | | | | | Sunburn protection only |
| M-pede | | | | 2 | | Thrips | Tank-mix partner |
| Malathion | P | | | 1 May | | Thrips | |
| Methomyl (Lannate) | A, P | | | 2–4 | | Thrips | Not considered as effective as it once was |

| Pesticides | Risks requiring mitigation | Preplant (Sept. – March) | Planting – emergence (March _April) | Vegetative growth (May – August) | Lifting, harvest and storage (August _ Sept.) | Target pests | Comments |
|---|---|---|---|---|---|---|---|
| **Insecticides** Products marked with ^ are go-to products; those marked with * are considered critical to the industry. | | **Number of applications per crop stage** ^ indicates critical use timing | | | | | |
| Methoxyfenozide (Intrepid) | | | | | | Cutworms and other Lepidoptera | Not used |
| Abamectin, cyantraniliprole (Minecto-Pro) | A,P | | | 1–2 | | Thrips, red spider mite | |
| Oxamyl (Vydate) | A,T,P,B | | 1 | 1–2 | | Thrips, nematodes | Can be applied via drip irrigation |
| Spinetoram (Radiant) | P | | | 2–3 | | Thrips | Most effective adulticide at present |
| Spinosad (Success) | P | | | 2 | | Thrips | Same mode of action as spinetoram but used less frequently |
| Spirotetramat (Movento) | ? | | | 2 | | Thrips (immatures) | Needs sufficient time to become active in plant |
| Sulfur | | | | | | | |
| Zeta-cypermethrin (Mustang Maxx) | A, P | | 1 | | | Cutworms, thrips | Use with caution; pyrethroid can flare thrips |
| Zeta-cypermethrin + abamectin (Gladiator) | A, P | | | 1 | | Thrips | Use with caution; pyrethroid can flare thrips |
| **Seed Treatments (reduced risks if used correctly)** | | | | | | | |
| Clothianidin + imidacloprid (Sepresto seed treatment) | A, P | 1 | | | | Onion and seedcorn maggot; wireworm; white grub | |
| Thiamethoxam Cruiser | A,P | 1 | | | | Onion and seedcorn maggot; wireworms | |
| Spinosad (Regard) | P | 1 | | | | Onion and seedcorn maggot | |
| **Fungicides** | | | | | | | |
| Acibenzolar S-methyl (Actigard) | | | | | | IYSV | Unknown activity to mitigate iris yellow spot virus |
| Azoxystrobin (Quadris)^ | A | | 1 | | | General fungal disease suppression | |
| *Bacillus subtilis* (Serenade) | | | | 1 | | Botrytis neck rot and leaf blight | Limited use currently |

| Pesticides | Risks requiring mitigation | Preplant (Sept. – March) | Planting – emergence (March _ April) | Vegetative growth (May – August) | Lifting, harvest and storage (August _ Sept.) | Target pests | Comments |
|---|---|---|---|---|---|---|---|
| **Insecticides**<br>Products marked with ^ are go-to products; those marked with * are considered critical to the industry. | | **Number of applications per crop stage**<br>^ indicates critical use timing | | | | | |
| Boscalid (Endura) | | | | 1–2 | | Botrytis leaf blight, purple blotch | |
| Chlorothalonil (Bravo)* | A, T | | | 1–2 | | Botrytis leaf blight, purple blotch | |
| Copper hydroxide (Kocide) | T | | | 1 | | Bacterial suppression | Must be applied before or immediately after rain/hail for efficacy |
| Copper hydroxide + copper oxychloride (Badge) | T, P | | | 1 | | Bacterial suppression | Must be applied before or immediately after rain/hail for efficacy |
| Dicloran (Botran) | T, B | | | 1 | 1 | Botrytis neck rot and leaf blight | |
| Fludioxonil + famoxadone (Tanos) | A, T | | | 1 | | | |
| Fluopyram + pyrimethanil (Luna Tranquility) | T | | | | | Botrytis neck rot and leaf blight, Stemphylium leaf blight, purple blotch | |
| Mancozeb (Dithane)* | T | | | 1–2 | | Botrytis neck rot and leaf blight | |
| Mancozeb + copper hydroxide (Mankocide)^ | | | | 2 | | Botrytis leaf blight, bacterial suppression | |
| Mefenoxam (Ridomil) | | | | | | *Pythium* spp. | |
| Metalaxyl | A | | | | | *Pythium* spp. | |
| Penthiopyrad (Fontelis)* | | | | 1–2 | | Pink root, *Botrytis* neck rot and leaf blight, Stemphylium leaf blight, purple blotch | |
| Pyraclastrobin (Cabrio)^ | A | | | | 2 | Stemphylium leaf blight, purple blotch | Used in last month prior to lifting |
| Pyraclastrobin + boscalid (Pristine)^ | A | | | 2 | | *Botrytis* neck rot and leaf blight, Stemphylium leaf blight, purple blotch | Used in last month prior to lifting |
| Sulfur | | | | 1 | | Powdery mildew | |
| Tebuconazole (Tebucol) | | | | | | Purple blotch | Under evaluation for activity against Fusarium proliferatum |
| Thiram | | | 1 | | | Damping-off diseases | Seed treatment |

| Pesticides | Risks requiring mitigation | Preplant (Sept. – March) | Planting – emergence (March _ April) | Vegetative growth (May – August) | Lifting, harvest and storage (August _ Sept.) | Target pests | Comments |
|---|---|---|---|---|---|---|---|
| **Insecticides** Products marked with ^ are go-to products; those marked with * are considered critical to the industry. | | **Number of applications per crop stage** ^ indicates critical use timing | | | | | |
| Zoxamide + mancozeb (Gavel) | T | | | | | *Botrytis* neck rot and leaf blight, Stemphylium leaf blight, purple blotch | |
| **Fumigants** | | | | | | | |
| Chloropicrin | | | | | | Soilborne diseases, nematodes, suppression of wireworms, grubs, some weeds | |
| Chloropicrin + 1,3-dichloropropene (Telone) | A, T, P, B | 1 | | | | Soilborne diseases (including pink root), nematodes, suppression of wireworm, grubs, some weeds | |
| Metam potassium (K-Pam) | A, T | 1 | | | | Soilborne diseases, including pink root and nematodes | |
| Metam sodium (Vapam) | A, T | 1 | | | | Soilborne diseases, including pink root and nematodes | |
| **Herbicides** | | | | | | | |
| 2,4-D | | | | | | | Only preceding fall |
| Bensulide (Prefar) | | 1 | | | | | Only at preplant |
| Bromoxynil (Buctril) | | | | 2 | | Broadleaves | Low rate/high volume |
| Clethodim (Select/Select Max) | | | | 2–3 | | Grasses | Surfactant needed |
| DCPA (Dacthal) | | 1 | | | | Broadleaves | Expensive; groundwater concerns |
| Dimethenamid-p (Outlook) | | | | 1–3 | | | Depending on rate |
| EPTC (Eptam) | | 1 | | | | Yellow nutsedge | Fall application |
| Ethofumesate (Nortron) | | | 2 | | | Yellow nutsedge, broadleaves | |
| Fluazifop (Fusilade) | | | | 2–3 | | Grass weeds | |
| Fluroxypyr (Starane Ultra) | | | | 1–2 | | Kochia, field bindweed, volunteer potato | Could be very hard on onions |
| Glyphosate (Roundup)^ | | 1 | 1 | | | All weeds | Delayed preemergence |

| Pesticides | Risks requiring mitigation | Preplant (Sept. – March) | Planting – emergence (March _ April) | Vegetative growth (May – August) | Lifting, harvest and storage (August _ Sept.) | Target pests | Comments |
|---|---|---|---|---|---|---|---|
| **Insecticides** Products marked with ^ are go-to products; those marked with * are considered critical to the industry. | | **Number of applications per crop stage** ^ indicates critical use timing | | | | | |
| Oxyfluorfen (Goal 2XL/ GoalTender) | A, T | | | 2 | | Broadleaves | |
| Paraquat (Gramoxone) | T, B | 1 | 1 | | | All weeds | |
| Pendimethalin (Prowl 3.3EC/Prowl H2O) | T | | 1 | 1–2 | | Broadleaves and grasses | Delayed preemergence |
| S-metolachlor (Dual Magnum) | A | | | | | Yellow nutsedge, broadleaves and grasses | One fall application |
| Sethoxydim (Poast) | | | | 2–4 | | Grasses | Surfactant needed |
| Trifluralin (Treflan) | T | | | 1 | | | At layby as a directed spray to the soil between rows; incorporate immediately with sweeps or cultivator |

# Efficacy ratings tables

# Efficacy ratings for insect and nematode management tools in onion

**Rating scale: E** = excellent (90%–100% control); **G** = good (80%–90% control); **F** = fair (70%–80% control); **P** = poor (< 70% control); **?** = efficacy unknown in management system—more research needed

| Management tools | Bulb mites | Cutworms | Leafminer | Nematodes | Onion maggot | Onion thrips | Spider mites | Wireworms | Comments |
|---|---|---|---|---|---|---|---|---|---|
| **Registered chemistries** | | | | | | | | | |
| Abamectin (Agri-Mek) | | | G | | | F | G | | PHI 30 days |
| Azadirachtin (Azadirect) | | | | | | F–G | | | Generally used as a tank-mix partner |
| *Bt* products | | ? | | | | | | | Worm outbreaks rare |
| *Chenopodium ambrosioides* extract (Requiem) | | | | | | ? | | | Rarely used. |
| Chlorpyrifos (Lorsban) | | G | | | F-G | | | | |
| Cyazypyr (Exirel; Verimark) | | | | | | F-? | | | Limited use; questions about exposure and timing |
| Diazinon | | | | | | | | P–F | |
| Dinotefuran (Scorpion) | | | | | | F–G | | | Timing critical; lower pressure |
| Imidacloprid (Admire) | P | | | | G | P | | ? | Seed treatments better for maggot |
| Kaolin (Surround) | | | | | | | | | Only for sunburn management |
| Lambda-cyhalothrin (Warrior) | | | | | | P | | | Known resistance problems |
| M-pede | | | | | | F–G | | | Used as tank-mix with other products — not alone |
| Malathion | | | | | P | F | | | Use when low pressure, early |
| Methomyl (Lannate) | | | | | | P-F | | | Decline in efficacy, but widely used; harmful to beneficials |
| Methoxyfenozide (Intrepid) | | ? | | | | | | | Not much cutworm, little used |
| Oxamyl (Vydate) | ? | | | F | F | F | | ? | Aquatic buffer requirement; needs to be early; used in drip irrigation |
| Spinetoram (Radiant) | | | G | | | G | | | |
| Spinosad (Success) | | | G | | | G | | | Not used as frequently as spinetoram (Radiant) |
| Spirotetramat (Movento) | | | | | | G | | | Takes time to become active in plant |
| Sulfur | | | | | | | P | | Limited to no use |
| Zeta-cypermethrin (Mustang Maxx) | | | | | | P | | | Limited use |

| **Management tools** | **Bulb mites** | **Cutworms** | **Leafminer** | **Nematodes** | **Onion maggot** | **Onion thrips** | **Spider mites** | **Wireworms** | **Comments** |
|---|---|---|---|---|---|---|---|---|---|
| Zeta-cypermethrin + abamectin (Gladiator) | | | | | | F | | | Better to use Agri-Mek |
| **Seed treatments** | | | | | | | | | |
| Clothianidin + imidacloprid (Sepresto) | | | | | G | | | F | |
| Thiamethoxam (Cruiser) | | | | | G | | | F | |
| Spinosad (Regard) | | | | | | | | | |
| **Unregistered/new chemistries** | | | | | | | | | |
| Abamectim, cyantraniliprole (Minecto-Pro) | | | ? | | | F | ? | | New product with potential |
| Formetanate hydrochloride (Carzol) | | | | | | G | | | Previously registered; good residual activity has been demonstrated in recent research trials |
| Tolfenpyrad (Torac) | | | | | | ? | | | Currently under evaluation |

# Efficacy ratings for disease and pathogen management tools in onion

**Rating scale: E** = excellent (90%–100% control); **G** = good (80%–90% control); **F** = fair (70%–80% control); **P** = poor (<70% control); **?** = efficacy unknown—more research needed

| Management tools | Bacterial diseases | Black mold | Botrytis leaf blight | Botrytis neck rot | Downy mildew | Iris yellow spot virus | Fusarium plate rot | Nematodes | Pink root | Pythium (damping-off) | Rhizoctonia (damping-off) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Registered chemistries** | | | | | | | | | | | | |
| Acibenzolar S-methyl (Actigard) | | | | | | | | | | | | Unknown activity against IYSV and other diseases |
| Azoxystrobin (Quadris) | | | | | | | | | | G–E | G | |
| *Bacillus subtilis* (Serenade) | | | | | | | | | P | | | Newer product; limited efficacy information |
| Boscalid (Endura) | | | | | | | | | | | G | |
| Chlorothalonil (Bravo) | | | G | | | | | | | | | Not often used; in season use |
| Copper hydroxide (Kocide) | G | | | | | | | | | | | |
| Copper hydroxide + copper oxychloride (Badge) | | | | | | | | | | | | |
| Dicloran (Botran) | | | G | G | | | | | | | | Good efficacy against botrytis; Not commonly used |
| Dithane + copper (Mancocide) | G | | | | G | | | | | | | Can be preventative against downy mildew |
| Fludioxinil + famoxadone (Tanos) | G | | | | | | | | | | | |
| Fluopyram + Pyrimethanil (Luna Tranquality) | | | | | | | | | | | | Newer product; limited efficacy information |
| Mancozeb (Dithane) | | | | | G | | | | | | | In-season use; Can be preventative against downy mildew |

| Management tools | Bacterial diseases | Black mold | Botrytis leaf blight | Botrytis neck rot | Downy mildew | Iris yellow spot virus | Fusarium plate rot | Nematodes | Pink root | Pythium (damping-off) | Rhizoctonia (damping-off) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mefenoxam | | | | | | | | | | F | | Used in seed treatment |
| Metalaxyl | | | | | | | | | | F | | Used in seed treatment |
| Penthiopyrad (Fontelis) | | | | F | | | | | F | | G | |
| Pyraclostrobin (Cabrio) | | | G | G | | | | | | | | |
| Pyraclostrobin + boscalid (Pristine) | | ? | | G | | | | | | | | |
| Sulfur | | | | | | | | | | | | Provides control for powdery mildew when present (not often present); also provides thrips suppression through irrigation |
| Tebuconazole (Tebucol) | | | | | | | | | | | | |
| Thiram | | | | | | | | | | | | Not often used |
| Zoxamide + Mancozeb (Gavel) | | | | | | | | | | | | |
| **Fumigants** | | | | | | | | | | | | |
| Chloropicrin | | | | | | | G | G | G | F | F | |
| Chloropicrin + Dichloropropene (Telone) | | | | | | | G | G | G | F | F | |
| Metam potassium (K-Pam) | | | | | | | G | F-G | F-G | F | F | |
| Metam sodium (Vapam) | | | | | | | G | F-G | F-G | F | F | |
| **Cultural/nonchemical** | | | | | | | | | | | | |
| Cultivar selection | | | | | | G–F | | | G | | | |

# Efficacy ratings for weed management tools in onion

**Rating scale: E** = excellent (90%–100% control); **G** = good (80%–90% control); **F** = fair (70%–80% control); **P** = poor (<70% control); **?** = efficacy unknown—more research needed

Note: Weed size or stage of growth is an important consideration with most postemergence herbicides.

In “Type” column, Pre = soil-active against preemerged weeds; Post = foliar-active against emerged weeds.

| Management tools | Type (Pre/ Post) | Common lambsquarters | Common purslane | Hairy nightshade | Kochia | Redroot pigweed | Volunteer potato | Yellow nutsedge | Annual grasses (Barnyard grass) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| **Registered chemistries<br>Weed size matters; assumes onions at ≥ two leaves; weeds 1–2” high** | | | | | | | | | | |
| 2,4-D | | | | | | | | | | Used to control field bindweed during preceding fall only; no in-season use |
| Bensulide (Prefar) | Pre | P–F | P–F | P–F | P–F | G | P | | E | Not used much; not effective |
| Bromoxynil (Buctril) | Post | G | P | F-G | F | F | | | P | |
| Clethodim (Select/Select Max) | Post | | | | | | | | E | Add a nonionic surfactant (MSD) at 0.25% v/v to improve efficacy |
| DCPA (Dacthal) | Pre | F | | F | F | P | | | G | Not used; expensive; issues with groundwater contamination |
| Dimethenamid-p (Outlook) | Post | F | P | G–P | P | P | F–G | P | G | Can be applied through drip irrigation to yellow onions (SLN label in Idaho, Malheur County). Application timing critical; poor if used post-emergence except through drip irrigation |
| EPTC (Eptam) | Pre | | | | | | | P–F | | Apply during preceding fall and immediately incorporate to avoid volatilization |
| Ethofumesate (Nortron) | Post | F | F | F | F | F | F–P | | | Needs moisture to activate herbicide |

| Management tools | Type (Pre/ Post) | Common lambsquarters | Common purslane | Hairy nightshade | Kochia | Redroot pigweed | Volunteer potato | Yellow nutsedge | Annual grasses (Barnyard grass) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Fluazifop (Fusilade) | Post | | | | | | | | E | Add crop oil concentrate (COC) at 1% v/v or nonionic surfactant (NIS) at 0.25%–0.5% v/v to improve efficacy |
| Fluroxypyr (Starane Ultra) | Post | F–G | | F–G | E | F–G | E | | | Volunteer potato, kochia, and other susceptible weeds should be 4–8” tall |
| Glyphosate (Roundup) | Post | G | F | G | P–G | G | | | E | Timing issues, weed resistance |
| Metampotassium (K-pam) (fumigant) | | | | | | | | | | |
| Metam sodium (fumigant) | | | | | | | | | | |
| Oxyfluorfen (Goal 2XL/ GoalTender) | Post | F | F | G | F | G | | | P | For optimum results, susceptible weeds should be 2–4” tall |
| Paraquat (Gramoxone) | Post | E | E | E | E | E | | | G | Better on small weeds with high volume for complete coverage |
| Pendimethalin (Prowl 3.3EC/Prowl H2O) | Pre/ Post | G | F–G | F | F | F | | | G | Could be applied delayed preemergence and postemergence |
| S-metolachlor (Dual Magnum) | Fall appli- cation | P | P | P | P | P | G | P | P | Fall applications to manage yellow nutsedge |
| S-metolachlor (Dual Magnum) | Post | P | P | P | P | P | P | | G | At layby will not control emerged weeds |
| Sethoxydim (Poast) | Post | | | | | | | | G | Add nonionic surfactant (MSD) to improve efficacy |
| Trifluralin (Treflan) | Post | P | P | P | G | P | | | G | Directed spray to soil between rows |

# Using PAMS Terminology

This system of terminology for IPM was developed for use by U.S. Federal agencies seeking to support adoption of IPM by farmers. The table below summarizes common tactics used in agricultural IPM using a "Prevention, Avoidance, Monitoring, Suppression" (PAMS) classification. We also define (in ***italics***) the ecological purpose that lies behind a particular practice. The PAMS tables throughout the text provide a simple basis for surveying practices that are used at different crop growth stages in terms of their contribution to a comprehensive IPM program.

## P PREVENTION

***Prevent introduction to the farm***
- Pest-free seeds, transplants

***Prevent reservoirs on the farm***
- Sanitation procedures
- Eliminate alternative hosts
- Eliminate favorable sites in and off crop

***Prevent pest spread between fields on the farm***
- Cleaning equipment between fields

***Prevent pests developing within fields on the farm***
- Irrigation scheduling to prevent disease development
- Prevent weed reproduction
- Prevent pest-susceptible perennial crops by avoiding high-risk locations

## A AVOIDANCE

***Avoid host crops for the pest***
- Crop rotation

***Avoid pest-susceptible crops***
- Choose genetically resistant cultivars
- Choose cultivars with growth and harvest dates that avoid the pest
- Place annual crops away from high-risk sites for pest development (even parts of a field)

***Avoid crop being the most attractive host***
- Trap cropping
- Use of pheromones
- Use crop nutrition to promote rapid crop development

***Avoid making the crop excessively nutritious***
- Use nutrition to promote rapid crop development
- Avoid excessive nutrients that benefit the pest

***Avoid practices that increase the potential for pest losses***
- Narrow row spacing
- Optimized in-row plant populations
- No-till or strip till

## M MONITORING

***Collect pests***
- Scouting and survey approaches
- Traps

***Identify pests***
- Use of identification guides, diagnostic tools and diagnostic laboratories

***Identify periods or locations of high pest risk***
- Use weather-based pest-development and risk models
- Use soil and plant nutrient testing

***Determine status and trends in pest risks and classify pest severity***
- Maintain pest records over time for each field

***Minimize pest risks over time***
- Plan an appropriate PAMS IPM strategy, based upon pest status and trends

***Determine interventions based upon risks and economics***
- Use of decision-support tools, economic thresholds

## S SUPPRESSION

### CULTURAL

***Outcompete the pest with other plants***
- Cover crops

***Suppress pest growth***
- Mulches

***Suppress pest with chemicals from crops or other plantings***
- Bio-fumigant crops

### PHYSICAL

***Physically injure pest or disrupt pest growth***
- Cultivation
- Mowing
- Flaming
- Temperature management
- Exclusion devices

***Physically remove pests***
- Mass trapping
- Hand weeding

### BIOLOGICAL

***Suppress pest reproduction***
- Pheromones

***Increase pest mortality from predators, parasites, and pathogens***
- Conservation biological control
- Inundative release and classical biological control
- Use of pest antagonists

### CHEMICAL

***Use of least-risk, highest-efficacy pesticides***
- Use economic thresholds to determine that pesticide use is economically justified
- Use pesticides as a last resort, as part of a PAMS IPM strategy

Table: Paul Jepson, IPPC Oregon State University, paul.jepson@oregonstate.edu

# Pesticide Risk Classification

Paul Jepson, Oregon State University

The pesticide risk analysis is based on the Oregon State University Integrated Plant Protection Center's state-of-the-science risk assessment tool IPM PRiME, a risk model that identifies moderate to high (10% or greater) risk (Jepson et al., 2014, Sustainable Agriculture Network 2017). We analyzed a total of 800 pesticides, and 168 of these posed risks to human workers and bystanders, aquatic life, wildlife, and pollinators. The analysis is intended to provide guidance that is supplementary to the label, which is the primary source of risk management information and mandatory practices.

### 1. Risk to aquatic life

Pesticides qualified for this risk category if one or more IPM PRiME aquatic risk models (aquatic algae, aquatic invertebrates, or fish chronic risk) exhibited high risk at a typical application rate.

### 2. Risk to terrestrial wildlife

Pesticides qualified for this risk category if one or more IPM PRiME terrestrial risk models (avian reproductive, avian acute, or small mammal risk) exhibited high risk at a typical application rate.

### 3. Risk to pollinators

Pesticides were selected based on a widely-used hazard quotient (HQ) resulting of pesticide application rate in g a.i./ha, and contact LD50 for the honey bee (*Apis mellifera*). Values of $HQ < 50$ have been validated as low risk in the European Union, and monitoring indicates that products with an $HQ > 2{,}500$ are associated with a high risk of hive loss. The HQ value used by IPPC is $>350$, corresponding to a 15% risk of hive loss. The quotient includes a correction for systemic pesticides, where risks to bees are amplified.

### 4. Inhalation risk

Inhalation risk to bystanders was calculated using the IPMPRiME model for inhalation toxicity (Jepson et al., 2014) calculated on the basis of child exposure and susceptibility. This index is protective for workers who may enter fields during or after application, and also bystanders.