Onion *ipmPIPE*: A Coordinated Effort to Improve the Management of Onion Thrips and *Iris yellow spot virus* for the U.S. Onion Industry


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**ABSTRACT**

Onion (*Allium cepa*) is an economically important vegetable crop in the United States, generating nearly $900 million annually in farm receipts. Pests such as onion thrips (*Thrips tabaci*) and a thrips-transmitted virus disease, *Iris yellow spot* (IYS), caused by *Iris yellow spot virus* (IYSV), have emerged in recent years as high priority, invasive, or potential threats to sustainable onion production throughout the United States and the world. The long-term goal of a recent United States Department of Agriculture (USDA)-National Institute of Food and Agriculture (NIFA)-Specialty Crop Research Initiative (SCRI) funded project was to optimize sound pest management decision making in onion through the development and deployment of a sustainable online information management platform called the Onion *ipmPIPE* (*ipm* integrated pest management Pest Information Platform for Extension and Education). Project participants in seven states generated an average of 500 reports annually on the occurrence of 20 priority insect pests and plant diseases, and enhanced the timeliness and effectiveness of IPM strategies implemented by the growers and industry locally and regionally in response to these reports. Thrips populations are generally greatest at all locations during July and August of each year, which compounds plant responses to environmental stresses such as temperature and limited or lower quality (e.g., saline) irrigation water. The increase in numbers of thrips (majority being *T. tabaci*) also aggravates problems with the onion thrips-transmitted virus IYSV (mentioned above) and IYS, which generally increases in incidence and severity during this same period. A comprehensive website (http://www.alliumnet.com/IPMPipe.html) and educational materials (bulletin, diagnostic cards, videos) were developed in response to the insect and disease threats, and have been shared with onion stakeholders throughout the United States and elsewhere. The project is also developing risk assessment models, a smartphone app, onion growing-degree-day review for efficacy of the current model based on 5.5°C from planting, and enhanced pathogen diagnostic tools for future testing and validation by onion stakeholders. Visiting the Onion *ipmPIPE* website was estimated by respondents to increase onion yields by 280 kg/hectare and reduce pesticide costs by $910/hectare on average. The Onion *ipmPIPE* platform is scale neutral, and supports a range of organic and conventional growers producing onions on small plots to large-scale commercial fields. Increased participation of stakeholders, including consumers, in a national educational project such as Onion *ipmPIPE* will better serve current and future interests in sustainability and profitability of critical food crops for the U.S. marketplace.

**INTRODUCTION**

Onion (*Allium cepa*) is an economically important vegetable crop in the United States, generating more than $900 million annually in farm receipts from 2004 to 2013 (USDA-ERS 2014). Onion production in the United States (Fig. 1) averages more than 60,000 ha annually. Although over 80% of the summer production (45,000 ha) occurs in the western states, economically important allium crops are grown in the eastern United States (e.g., Georgia, Michigan, and New York). Furthermore, a significant portion of the U.S. and world supply of onion seed is produced in the Pacific Northwest (PNW) region of the United States. Pests such as onion thrips (*Thrips tabaci*) (Fig. 2) and a thrips-transmitted virus disease *Iris yellow spot* (IYS) (Fig. 3), caused by the tospovirus *Iris yellow spot virus* (IYSV), have emerged in recent years as high priority, invasive, or potential threats to sustainable onion production throughout the United States, Canada, and Mexico (Bag et al. 2014; Gent et al. 2006; Pappu et al. 2006). These pests and others of regional or local importance represent an immediate and serious threat to sustainable onion production in the United States. Confirmation of IYS presence in numerous onion-producing countries worldwide emphasizes the need to develop economically sound and effective integrated pest management (IPM) strategies for the IYSV-thrips complex (Gent et al. 2006; Pappu 2009).

Projected economic losses attributed to IYSV and thrips could reach $60 to $90 million (10 to 15% of total farm gate value and up to 100% in individual grower fields). Moreover, environmental and economic costs for pesticide sprays to control thrips add another $7.5 to $12.5 million (3 to 5 additional sprays on 48,500 ha per year) (Gent et al. 2006). The rapid and international spread of this disease emphasizes the need to develop economical and effective IPM strategies, and led to the development of a national committee of researchers and extension specialists to share their expertise and resources with those of onion stakeholders to prioritize pest management and production projects at the state, regional, and national levels (W2008 Committee, [http://www.alliumnet.com/w1008committee.html](http://www.alliumnet.com/w1008committee.html); U.S. Onion Pest Management Strategic Plan, [http://www.ipmcenters.org/pmsp/pdf/USonionPMSP.pdf](http://www.ipmcenters.org/pmsp/pdf/USonionPMSP.pdf)).

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In 2010, onion research and extension personnel with support from onion growers and the industry received funding from the United States Department of Agriculture-National Institute of Food and Agriculture-Specialty Crop Research Initiative (USDA-NIFA-SCRI) competitive grant program for an ambitious project to address some of the critical needs of the U.S. onion industry. The long-term goal was to optimize sustainable pest management decision making for onions by the development and deployment of an online information management platform (IPMCENTERS 2013) called the Onion ipmPIPE (Onion integrated pest management Pest Information Platform for Extension and Education) (http://www.alliumnet.com/IPMPipe.html). Objectives included creation of an ipmPIPE Network and operations to: (a) validate scouting protocols for priority pests of onion with an emphasis upon IYSV and onion thrips; (b) provide critical

**FIGURE 1**

Irrigated field of seeded onions grown in the western United States. (Photo by H. F. Schwartz)

**FIGURE 2**

Onion thrips larvae feeding in axil of onion leaves. (Photo by H. F. Schwartz)

**FIGURE 3**

Onion plant symptoms (lesions and foliage death) typical of Iris yellow spot. (Photo by H. F. Schwartz)
management tools to stakeholders, including plant and pest phenology that relates growth stages to weather, pest, and disease thresholds, and timely management strategies; (c) enhance management resources to include an image gallery to aid in-field and laboratory identification of key diseases and insects linked to a wiki-information tool to provide additional background information on biology and management; and (d) assess the adoption level of tools and resources by growers, advisors and other key stakeholders. Other objectives and efforts are still in progress and include: (a) incorporation of economic justification to implement risk assessment models for onion insects and diseases; and (b) development and enhancement of a DNA macroarray for detection and differentiation of bacterial and fungal pathogens affecting onions in the field and in storage. The following sections provide an overview of progress made to date, and describe some of the challenges and opportunities associated with these components by users, including onion specialists, diagnosticians, and stakeholders.

VALIDATE SCOUTING PROTOCOLS FOR PRIORITY PESTS AND DISEASES

Onion Sentinel Monitoring (SM) involved multiple locations (e.g., three or more cooperator fields, experiment station sites, and/or survey transects) in representative onion production areas of seven states: Colorado, Idaho, Michigan, New Mexico, New York, Utah, and Washington. SM required regular field visits (approximately every two weeks to >40 sites in the seven states annually) during key onion growth periods for the 16 to 20 week-long growing season in each of 2011 to 2013 (Fig. 4). State specialists conducted periodic mobile surveys through key production regions in their state to generate additional pest activity data (e.g., in Colorado a 25-km transect was overlaid through northern, southern and western onion production regions so that key commercial production areas could be monitored through the season). State disease and insect pest reports were submitted biweekly, and compiled for timely state/regional/national reporting to growers, crop consultants, and other project stakeholders (including university and industry representatives interested in this project from California and Pennsylvania) during periodic conference calls and online at the Onion ipmPIPE website. Field sampling and diagnostic protocols were developed for priority pests and diseases discussed later in the paper, resulting in more uniform, timely, and accurate identification and enumeration of pests and diseases affecting allium crops.

The focus of crop and pest monitoring was to relate onion vegetative and reproductive growth stages to thrips population estimates (average number of thrips larvae and adults per 5–10 plants sampled at 5–10 sites/field) (Fig. 5), IYS presence (asymptomatic and symptomatic) and severity, and the incidence of other insect and disease problems affecting onion crops in the United States (Schwartz and Mohan 2008). This relationship has been important to improve our understanding of the epidemiology of these pests, and to enhance the timing and effectiveness of pest management strategies for representative production systems in onion regions of the country.

Figure 6 illustrates the number of pest and disease reports that were compiled annually from more than 40 monitoring sites throughout seven onion-producing states during 2011 to 2013 by project specialists and stakeholders. Project participants provided...
an average of 500 reports annually on the occurrence of 20 priority insect pests and plant diseases. These reports enhanced the timeliness and effectiveness of IPM strategies implemented by the participating onion growers locally and regionally in response to these reports. The majority of reports dealt with enumeration and speciation of thrips (primarily *T. tabaci*), and enabled measurement of thrips and vector populations throughout the participating states and over time.

Bacterial and fungal diseases varied considerably across locations and years: *Pantoea* spp. (cause of center rot and soft rot) (Fig. 7) were the most frequent and consistent bacterial pathogen (49% of samples); *Botrytis* spp. (cause of neck rot and a leaf spot) (Fig. 8) were the most common foliar/bulb fungal pathogen reported (56% of samples); and *Phoma terrestris* (cause of pink root) (Fig. 9) was the most prevalent soilborne pathogen (58% of samples). Other bacterial diseases included sour skin, brown rot, and Xanthomonas leaf blight (Fig. 10); in addition to a phytoplasma problem (Fig. 11). Other fungal or fungal-like pathogens included *Peronospora destructor* (cause of downy mildew) (Fig. 12), *Alternaria porri* (cause of purple blotch) (Fig. 13), *Entyloma* spp. (cause of smut) (Fig. 14), and diseases caused by species of *Cladosporium*, *Colletotrichum*, *Fusarium* (Fig. 15), *Rhizoctonia*, and *Stemphylium*. As expected, the most common viral disease (98% of samples) was IYS which was targeted in this project and diagnosed each year in all seven states.

![Figure 7](image7.png)

**FIGURE 7**
Bulb discoloration caused by *Pantoea ananatis* infection. (Photo by H. F. Schwartz)

![Figure 8](image8.png)

**FIGURE 8**
*Botrytis acalada* infection of an onion neck and bulb tissue. (Photo by H. F. Schwartz)

![Figure 9](image9.png)

**FIGURE 9**
Bulb and root infection by the pink root fungus, *Phoma terrestris*. (Photo by H. F. Schwartz)

![Figure 10](image10.png)

**FIGURE 10**
Necrosis and watersoaking of onion leaves caused by *Xanthomonas axonopodis pv. allii*. (Photo by H. F. Schwartz)
FIGURE 11
Phytoplasma symptoms of chlorotic and twisted leaves on an onion plant. (Photo by H. F. Schwartz)

FIGURE 12
Downy mildew affected onion plants with necrotic foliage. (Photo by H. F. Schwartz)

FIGURE 13
Purple blotch lesions and necrosis on onion leaves. (Photo by H. F. Schwartz)

FIGURE 14
Smut lesions containing dark-colored teliospores on onion plants. (Photo by H. F. Schwartz)
Onion thrips was the predominant insect identified (86% of samples), followed by western flower thrips (*Frankliniella occidentalis*), especially in the western states. Other insect pests included seedcorn maggot (*Delia platura*) (Fig. 16), onion maggot (*D. antiqua*), leafminers (*Liriomyza* spp.) (Fig. 17), green peach aphid (*Myzus persicae*), and the yellow-striped armyworm (*Spodoptera ornithogalli*).

Figure 18 illustrates the variation in thrips populations over time and locations during the 3-year period. Western states, such as Colorado, Idaho, and Utah, generally sustained greater populations (a maximum density of 200 to 400 thrips/plant by the end of the monitoring period) than the other participating onion-growing states. Thrips populations were generally greatest during July and August of each year, which compounds plant responses to environmental stresses such as temperature and limited or lower-quality (e.g., saline) irrigation water. The increase in numbers of thrips also aggravates problems with the thrips-transmitted virus IYSV, which generally increases in incidence and severity during this same time (Gent 2006). Thrips samples collected during this project are being tested to verify the incidence of thrips viruliferous for IYSV.

**PROVIDE MANAGEMENT TOOLS TO STAKEHOLDERS**

The Onion *ipmPIPE* project evolved in scope and interactivity with state, regional, and national stakeholders and organizations involved with the production, pest management (emphasis upon IPM strategies including selection of disease resistant varieties, planting clean seed, suitable crop rotation, scouting and confirmation of economic threats from disease organisms and insect pests, and timely application of pesticides as needed), and marketing of allium crops such as onion and garlic.

Field data collected by project participants was uploaded to the Onion *ipmPIPE* web site (hosted by Planalytics, Berwyn, PA; with support from BugwoodImages, University of Georgia, Tifton, GA; Multigrain International LLC, Fort Collins, CO; and Alliumnet, Colorado State University, Fort Collins, CO), which includes a series of menus, maps, reports, illustrations, and management links related to onion pest and disease priorities. Diagnostic aids, including a comprehensive production and pest management bulletin (Schwartz and Bartolo 2013) featuring many of the Onion *ipmPIPE* resources, were distributed to onion stakeholders across the United States and internationally to promote management practices and the *ipmPIPE* project (Fig. 19).

A series (Onion *ipmPIPE* 2011) of eight, two-page, pocket-sized field cards describing onion growth stages, diseases, insects (pests and vectors), and abiotic problems was delivered to more than 8,000 stakeholders throughout North American allium-growing regions; these cards also are available online as PDFs (see sidebar below). This series has enhanced the accuracy and efficiency of communications and recordkeeping by project.

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**Onion *ipmPIPE* Pocket Series, 2-page diagnostic cards:**
[http://www.alliumnet.com/IPMPipetalksandpubs.html](http://www.alliumnet.com/IPMPipetalksandpubs.html)

- Storage Fungal Diseases
- Foliar Fungal Diseases
- Onion Insect Pests
- Virus Diseases
- Bacterial Diseases
- Storm Damaged Onions
- Bulb Growth Stages of Onion
- Soil-borne Diseases

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**FIGURE 16**
Seedcorn maggot larva. (Photo by W. S. Cranshaw)

**FIGURE 17**
Leafminer injury to onion leaf. (Photo by H. F. Schwartz)

**FIGURE 15**
Fusarium damaged basal plates and roots of onion bulbs. (Photo by H. F. Schwartz)
FIGURE 18
Maximum thrips density (larvae and adults) per plant at one of several monitoring sites recorded by project specialists and stakeholders monitoring onion crops in Colorado, Idaho, Michigan, New Mexico, New York, Utah, and Washington during May to September of each of 2011 to 2013.

FIGURE 19
Examples (left) of educational materials (bulletin and diagnostic cards) developed in response to the insect and disease threats to onion production in the United States and elsewhere. These resources are available as PDF files at [http://www.alliumnet.com/IPMPipetalksandpubs.html](http://www.alliumnet.com/IPMPipetalksandpubs.html), with additional resources (right) hosted by Bugwood ([http://wiki.bugwood.org/HPIPM:Onion](http://wiki.bugwood.org/HPIPM:Onion)).
Additional educational resources include a series of disease and insect diagnostic videos posted on YouTube and various products from the Bugwood wiki for easy access by stakeholders including the following titles: IYSV and Thrips, Xanthomonas Leaf Blight, Downy Mildew, and Botrytis and Purple Blotch, which are listed at http://apps.planalytics.com/aginsights/pipehome.jsp?detail=image.

ENHANCE MANAGEMENT RESOURCES

The Onion *ipm*PIPE project has also promoted the use and future validation of various onion pest and disease risk assessment models based upon key factors related to pest and pathogen biology, conditions favoring survival and pathogen infection, recent weather events (Fig. 20) and forecasts (temperature and moisture), crop history, irrigation and rainfall conditions, varietal susceptibility, and stage of crop development. For example, the IYSV and Thrips model (Fig. 21) is driven by high temperature and moisture stress, while other disease models (e.g., foliar fungal and bacterial diseases) are driven by cool to moderate temperature and high moisture conditions. Stakeholders can evaluate the status of these parameters throughout the production cycle to determine if their crop is at a low, moderate, or high risk for pest- and disease-induced losses, and then determine if an IPM response would be feasible and justified.

A smartphone app is being developed for use via a web-interface application that will be geo-referenced to collect, store, and transfer data to the project website with access to project resources on smart-phone platforms. The flexible app could be adapted to accommodate other crops (e.g., potato, legume, small grain) and their respective sets of pests and diseases in the future.

A group of project scientists is currently evaluating the functionality and reliability of onion growing degree day (GDD) models traditionally based on a base 42°F (5.5°C), using benchmark data collected by project participants over locations.

**FIGURE 20**
Measurement of local weather data in relation to the onion crop and pest activity. (Photo by H. F. Schwartz)
and years (Fig. 22). A validated or modified GDD model(s) will then be utilized by onion stakeholders and pest management personnel to link pest forecast and onion growth models for timely implementation of IPM strategies.

In addition, an innovative pathogen diagnostic and molecular-based detection method utilizing a DNA macroarray is under development for detection and differentiation of bacterial and fungal pathogens that can infect onions in the field and in storage. Such new diagnostic tools will allow differentiation of target pathogens from nonpathogenic organisms commonly associated with onion plants and bulbs (Schwartz and Mohan 2008).

OUTREACH PLAN

The outreach plan for the Onion ipmPIPE is multifaceted with a network of delivery systems extending through participating states and the internet. Project participants reviewed each portion of the outreach plan for content, ease of use, and importance. The Onion ipmPIPE project has developed into a collaborative online resource that combines the strengths and uniqueness of multiple entities including universities, the USDA, Planalytics, Multigrain, and Bugwood (Fig. 23). Alliumnet (http://www.alliumnet.com) serves as a portal to resources developed by the Onion ipmPIPE as well as other USDA-NIFA-SCRI onion projects funded in recent years for Translational Genomics and Storage Technology. One goal of the website is to remain as a central portal for archived and newly generated resources for the foreseeable future.

ADOPTION OF ONION IPMPIPE TOOLS AND RESOURCES

An online survey (e.g., pre/post knowledge, and to assess value) was developed and posted on priority websites such as Alliumnet.com to encourage public users to respond and evaluate the ipmPIPE component. Based on the results of surveys in 2012 and 2013, those respondents visiting the Onion ipmPIPE website increased onion yields by an estimated 280 kg/ha and reduced pesticide costs by $910/ha on average. The survey revealed that awareness (by more aggressive advertising) was a key factor in influencing visits to the website, and growers prefer pest management information in a form that can be readily applied on their farms. The Onion ipmPIPE website can be marketed more intensely to growers as well as extension agents/educators, crop consultants, trade groups, and other secondary sources of information for growers.

FIGURE 22
Baseline measurement of onion plant development to expand growth stage models. (Photo by H. F. Schwartz)

FIGURE 23
The Onion ipmPIPE has successfully strengthened its outreach efforts by linking multiple online resources.
The allium industry representing onion and garlic crops (2004 to 2013 records from the USDA Economic Research Service [USDA-ERS 2014]) has been impacted positively by the Onion ipmPIPE grant of $375,000 + PI resources of $500,000/year with a conservative return estimate of 5% ($52 million or an annual Return on Investment of 50 to 1) by reducing losses from pests and diseases to onion crops grown on 70,000 ha and valued at $860 million value ($43 million return), and garlic crops grown on 12,000 ha and valued at $172 million value ($9 million return). Additional savings include reduced numbers of application of pesticides when insect and disease pressures were estimated to be too low to warrant additional IPM action; however, data was not available on specific amounts of pesticide applied during this reporting period.

The challenge now is to establish an economic justification for sustaining the Onion ipmPIPE and other ipmPIPE projects. The Onion ipmPIPE enhances the role of pest management specialists by providing near real-time access to observations and alerts, model output, pest management information and guidelines from state, regional, and national resources. Communication tools also allow specialists to customize information for dissemination to state and regional crop consultants and growers (Schwartz 2009). The platform is scale neutral and supports a range of organic and conventional growers producing onions on small plots to large fields throughout the United States. The onion industry and other stakeholders, including consumers, are encouraged to increase participation and support of this type of project that serves current and future interests as well as the sustainability of this critical food crop for the U.S. marketplace.

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LITERATURE CITED AND FURTHER READING


IPMCENTERS. 2013. Pest Management Strategic Plan for Dry Bulb Storage Onions in the United States. USDA-NIFA, Western IPM Center (contact agency), Davis, CA.


http://www.alliumnet.com/IPMPipetalksandpubs.html


