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Extension Impacts on Onion IPM: Current Perspectives from the Industry

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Abstract. An assessment was conducted to evaluate perceived risk from the most serious pests and diseases facing the allium industry and to identify practices that would improve adoption of integrated pest management (IPM). The survey was administered to growers attending annual onion production and management meetings in Oregon and New York. Results indicate that thrips and thrips-vectored Iris Yellow Spot Virus were perceived as a high-risk problem by 87% of respondents. Demonstrating the efficacy of IPM on a commercial scale and improving collaborative efforts between universities and growers were identified as high impact practices to improve adoption of IPM.

INTRODUCTION

Dry bulb storage onions are produced on approximately 95,000 acres across the United States (National Agricultural Statistics Service [NASS], 2023). In the Pacific Northwest region of the United States, storage onion production is largely concentrated in the Snake River valley of Southwestern Idaho and Eastern Oregon, an area collectively referred to as the Treasure Valley. Approximately 20,000 acres of onions are planted annually in the region, accounting for over 25% of U.S. storage onion production (NASS, 2023). On the east coast, onion production is concentrated in the state of New York. Approximately 6,800 acres are planted in the state annually, accounting for about 5% of U.S. storage onion production (NASS, 2023).

Onion production in the United States is characterized by an intensive management strategy that typically relies on heavy input use (Alyokhin et al., 2020; Greenway, 2021). The large investment in resources required to produce a highly valuable allium crop subjects growers to high levels of risk from factors that might threaten its production. For example, onion yield loss from onion thrips damage and the onion thrips vectored iris yellow spot virus (IYSV) pathogen pose serious threats to economically viable onion production in growing regions across the United States and worldwide (Gill et al., 2015). Currently, the management of onion thrips and IYSV is characterized by the application of multiple insecticides throughout the growing season (Leach et al., 2017; Nault & Huseth, 2016; Nault & Shelton, 2010; Regan & Nault, 2022; Reitz, 2014; Rondon et al., 2018; Waters, 2011). Costs for season-long insecticide application programs will vary, but typical spray regimes have been estimated to range from $188 to $326 per acre (Greenway, 2021; Leach et al., 2019; Waters, 2011).

Despite the high cost of insecticide programs to manage onion thrips and IYSV in onions, growers have historically been reluctant to adopt integrated pest management (IPM)-based approaches for thrips management (Hoffman et al., 1995). A lack of IPM adoption in onions is consistent with that in other high-value crops, where use of IPM has been found to be dependent on the perception of the lack of large benefits over existing practices (Fabre et al., 2007; Gent et al., 2011). A recent survey further detailed the continual challenges associated with IPM adoption as perceived by stakeholders and IPM practitioners (Lane et al., 2023). However, evolving resistance of onion thrips to classes of insecticides has been a well-documented concern worldwide (Aizawa et al., 2016; Foster et al., 2010; Herron et al., 2008; Shelton et. al., 2006;). Concerns regarding resistance, in combination with the limited number of available insecticides for thrips management (Crop Data Management System, 2022), have intensified the need for improved management tactics. Recent price volatility of key inputs, including fertilizers and insecticides, and a heightened level of onion price volatility

have exposed onion producers to a more pronounced level of financial vulnerability, further compounding the need for alternative approaches to managing the valuable crop (Agricultural Marketing Service, 2021; NASS, 2020, 2022).

Though less ubiquitous than onion thrips and IYSV, white rot also presents a continuing research need for the onion industry. The potential for devastation from white rot is illustrated by previous research (Crowe & Hall, 1980) documenting the ability of a single sclerotium per kilogram of soil to correspond with a 50% disease incidence. The ability of sclerotia to survive for over 20 years without a host plant further illustrates the long-term impacts of the disease (Davis, 1990). Furthermore, the causal agent of white rot has become more established in the Pacific Northwest (Lupien et al., 2013; Woodhall et. al., 2022). Economically effective treatments for white rot are limited, and as a result, infection typically results in the inability to produce onion in perpetuity (Sammour et al., 2011). The impacts of white rot are typically ruinous; thus, even in areas with strict control efforts designed to assist in the prevention of the disease, growers have reason to fear white rot infection.

Researchers in major onion production regions across the United States sought to develop and evaluate sustainable IPM-based management tactics to address some of the most serious pests and diseases threatening the onion industry. Improving and refining managerial alternatives for onion thrips, IYSV, and white rot were integral components of the project. During the course of the project, we evaluated grower perceptions of pests and diseases affecting two U.S. onion growing regions and assessed attitudes regarding and perceptions of IPM-based practices for pest and disease management.

MATERIALS AND METHODS

The survey instrument was developed to take a holistic approach to understanding perceptions of IPM by growers in two major onion-producing regions of the United States. Our approach to assessment provided context to inform improved understanding of responses to questions specifically pertaining to IPM. The critical foundation for our analysis was in direct alignment with the directives of the U.S. Department of Agriculture (USDA) road map for IPM to improve "understanding of the social and cultural characteristics of pest management" (Agricultural Research Service, 2018, p. 4). As noted by previous researchers (Dara, 2019; Gott & Coyle, 2019), the human aspect of decision-making is integral for understanding IPM adoption, but it is often overlooked. As a result, we wanted to garner general information about our sample's age, primary sources of information, satisfaction with Extension, perceptions of risk from pests and diseases, willingness to adopt new approaches to management in general, and perceptions of the effectiveness of current pest and disease management tactics. The IPM-based section of the survey focused on improving understanding of a grower's management decision-making process, identifying the most effective tools to assist in IPM-based decision-making, and improving understanding of how the design of research projects and collaboration with growers can enhance IPM adoption.

The survey consisted of a total of 12 questions. One question was predicated on geography, and therefore restricted to participants in New York. One question was eliminated due to a technical error that hindered accurate responses by the majority of growers in one region. Questions were presented in a variety of formats, including text entry, multiple choice questions, and Likert rankings (Likert, 1932). The survey instrument was reviewed by professionals affiliated with IPM coordination and Extension at the Oregon Integrated Pest Management Center and faculty at Oregon State University and Cornell University. Descriptive statistics tabulated in MS Excel were used to analyze the data.

The online survey was developed and administered using Qualtrics and distributed to a convenience sample of producers in attendance at annual onion grower meetings in Ontario, Oregon and Syracuse, New York. Hard copies of a quick response code linking participants to the survey were distributed to the audience, and one researcher in each region provided the code on a slide during their presentation. In New York, growers with active addresses on file with the principal researcher were also provided with an email link to the survey. An accurate sampling frame was not available because active participation in grower organizations is voluntary, and privacy restrictions limit disclosure of information pertaining to individual growers or grower groups. Despite data constraints, we acted on the guidelines of Baxter et al. (2015), who noted that the inability to obtain a perfect sample should not hinder efforts to conduct a survey. Previous literature further supports convenience sampling as a useful tool for investigation of certain topics such as business management, a key theme throughout our survey (Ellis et al., 2022; Peth & Mußhoff, 2020).

RESULTS AND DISCUSSION

DEMOGRAPHIC CHARACTERISTICS AND PERCEPTIONS OF EXTENSION

A total of 39 growers responded to the survey; 41% (16/39) were from western onion growing regions and 59% (23/39) were from growing regions in New York. Approximately 90% of growers completed all questions in the survey. The remaining 10% completed 97% of the survey but omitted the ranking of a single factor within it. The omission was likely inadvertent, given the respondents' complete answers to all other questions. We reported the results of all respondents but noted omitted rankings in the results when they occurred.

The age of participants ranged from 24 to 65; the median age was 42. The average was 44.95, indicating our sample was 12.55 years younger than the national average age of 57.5 reported for farm producers in the most recent census of agriculture (NASS, 2017). As depicted in Table 1, our sample was skewed toward a younger age group, with 69% of respondents being younger than the national average age of farm producers. The highest proportion of respondents, 38%, was under the age of 40. Approximately 31% were age 40 to 57, and 31% of respondents were over the age of 57.

A breakdown of satisfaction rankings pertaining to Extension programming and materials is provided in Table 2. Results indicated that 92% of participants were satisfied with the Extension service in their region. Approximately 8% reported being somewhat satisfied with Extension programs and materials. No respondents reported being dissatisfied or somewhat dissatisfied with Extension programming.

To improve understanding of where growers source management information, we asked participants to select all resources from which they typically sought knowledge pertaining to pest management. Extension publications, personnel, and workshops; local grower associations; private consultants; internet-based resources other than social media; neighboring farmers; and social media were included for selection. The age of our sample was skewed toward a younger demographic than the average age of farm producers reported by the USDA, but no participants reported using social media as a source of information. As reported in Table 3, the largest proportion of respondents reported using a single information source, which was Extension.

Table 1. Age Profile of Survey Respondents

Age (years)	Total (%)
<40	38
40-57	31
>57	31

Table 2. Extension Satisfaction Rankings

Response Category	Total (%)
Satisfied	92
Somewhat satisfied	8
Somewhat dissatisfied	0
Dissatisfied	0

The percentages of survey participants reporting use of all combinations of information resources are presented in further detail in Table 3.

PEST RISK ASSESSMENT AND NOVEL PEST MANAGEMENT ADOPTION ATTITUDES

To better understand research needs and to improve service to local grower communities, we asked participants to rank their level of perceived risk from the most serious problems facing the onion industry: onion thrips/IYSV and white rot. Strict control efforts have been implemented to assist in the prevention of white rot in the Treasure Valley of eastern Oregon and western Idaho, as well as other areas of the Pacific Northwest (Idaho State Department of Agriculture, 2010; Oregon Secretary of State Administration, 2022; Washington State Legislature, 2022). However, documented cases of white rot in other regions highlight the capacity of this disease to destroy an onion industry, as well as its potential to resurface after a period of eradication (Lupien et al., 2013; Stewart-Courtens, 2016; Woodhall et al., 2022). Thus, even if a particular region has not been affected by the disease, a priori knowledge of the disease creates the potential to elicit a high level of fear.

Onion thrips/IYSV was clearly identified as a serious concern by the majority of growers. As indicated in Table 4, onion thrips/IYSV was ranked as a high-risk problem by 87% of respondents. About 8% of respondents reported onion thrips/IYSV as a low concern, and 5% of survey participants reported onion thrips/IYSV as not being of concern in their region.

Respondents' perceptions of the perceived risk of white rot are also depicted in Table 4. About 26% of respondents did not perceive white rot as being a concern in their area, indicating a high level of confidence in local control efforts. Another 13% indicated no perception of risk from white rot. Slightly more than half of respondents recognized a level of risk from white rot but perceived the risk to be low. About 8% of respondents reported a perception of high risk associated with white rot.

Investment in research and development of new tactics and IPM-based approaches to management can only be successful if growers are willing to implement them. Accordingly, we evaluated growers' willingness to experiment with new approaches to managing onion pests and diseases. Responses pertaining to the willingness to try new approaches for thrips/IYSV are presented in Table 5. A large percentage of respondents, 58%, reported being very willing to experiment with new approaches for managing onion thrips/IYSV. Another 31% reported being willing to try new approaches to management. About 8% of respondents did not feel comfortable responding to the question because they did not perceive thrips/IYSV to be a concern in their

Table 3. Sources of Integrated Pest Management Information

Sources of information	Percent reporting
Extension (publications, personnel, and workshops)	36%
Extension (publications, personnel, and workshops) and private consultants	8%
Extension (publications, personnel, and workshops) and internet-based resources other than social media	8%
Extension (publications, personnel, and workshops), local grower association, and neighboring farmers	8%
Extension (publications, personnel, and workshops), local grower association, private consultants, internet-based resources other than social media, and neighboring farmers	5%
Local grower association	5%
Extension (publications, personnel, and workshops) and neighboring farmers	5%
Extension (publications, personnel, and workshops), local grower association, and private consultants	5%
Extension (publications, personnel, and workshops), internet-based resources other than social media, and neighboring farmers	3%
Extension (publications, personnel, and workshops), local grower association, and internet-based resources other than social media	3%
Extension (publications, personnel, and workshops), local grower association, internet-based resources other than social media, and neighboring farmers	3%
Internet-based resources other than social media	3%
Private consultants	3%
Extension (publications, personnel, and workshops), local grower association, private consultants, and internet-based resources other than social media	3%
Extension (publications, personnel, and workshops), local grower association, private consultants, and neighboring farmers	3%
Extension (publications, personnel, and workshops), private consultants, internet-based resources other than social media, and neighboring farmers	3%
Social media	0%

Table 4. Pest and Disease Risk Assessment

	Total (%)	
Response	**Thrips/IYSV**	**White rot**
High risk	87	8
Low risk	8	53
No risk	0	13
Not a concern in my region/I don't know	5	26

geographic region or simply did not know. No respondents reported being unwilling or very unwilling to experiment with new approaches to thrips/IYSV management.

The need to manage white rot will depend on region and, to some degree, on perceptions of the effectiveness of control orders designed to prevent the entry of the disease in onion growing regions. As depicted in Table 4, the majority of growers reported the perceived level of risk from white rot as low, a response likely attributable to vigilant exclusion efforts. However, somewhat surprisingly, when asked to report on their willingness to try new tactics to manage white rot, respondents reflected a proactive attitude toward new managerial tactics. We believe the positive responses depicted in Table 5 reflect forward thinking in support of white rot research, as well as proactive support of regulatory efforts to minimize introduction of the pathogen in unaffected

areas. We also believe the responses are likely indicative of legitimate fear and a heightened level of vulnerability resulting from the resurfacing of white rot in garlic crops after a long period of eradication in New York (Stewart & Hay, 2016) and relatively recent documentation of white rot becoming more established in the Pacific Northwest (Lupien et al., 2013; Woodhall et al., 2022).

As depicted in Table 5, results indicated that 28% of respondents did not perceive white rot as a concern in their region and, thus, did not feel comfortable asserting to adoption behavior of new managerial tactics. However, 36% indicated a willingness to adopt innovations in white rot management, while another 18% reported being very willing to try new approaches to white rot management. About 15% of respondents were somewhat willing to try new approaches to white rot management. About 3% of respondents reported being unwilling to implement new managerial approaches, and no respondents reported being very unwilling to try new approaches to white rot management.

Onion thrips has been a persistent pest of onion, and its management has presented significant concerns for growers because of its propensity to develop resistance to insecticides (Adesanya et al., 2020; Shelton et al., 2006; Waters & Walsh, 2011). As a result, we wanted to garner additional information regarding perceptions of current management tactics. We asked participants to provide insights into their level of confidence in the effectiveness of current management tactics for onion thrips and thrips-vectored IYSV. Results are presented in Table 6. Just 29% of respondents reported being very confident in the effectiveness of current strategies, while another 58% reported being somewhat confident in current management strategies. About 8% of respondents reported not being confident in the effectiveness of current strategies.

Reducing fertilizer rates has also been analyzed as a potential tool for improving management of onion thrips (Buckland et al., 2013; Leach et al., 2017; Malik et al., 2009; Regan & Nault, 2022). As a part of the project, we evaluated the impact of fertilization on thrips in the Treasure Valley of Idaho and eastern Oregon and throughout New York and found no impact on onion thrips populations (Chitturi et al., 2021; Regan & Nault, 2022). Standard rather than reduced fertilizer programs optimized yield of bulbs graded in the most valuable categories of large onions in the Treasure Valley (Chitturi et al., 2021). In contrast, in New York, neither total bulb yields nor the production of bulbs in larger size classes was affected by reductions in fertilizer use. Consequently, growers in New York could reduce fertilizer by one-half of what is typically applied without affecting yields (Regan &

Table 5. Willingness to Try New Approaches to Pest Management

	Total (%)	
Response	**Thrips/IYSV**	**White rot**
Very willing	59	18
Willing	31	36
Somewhat willing	3	15
Unwilling	0	3
Very unwilling	0	0
Not a concern in my region / I don't know	8	28

Table 6. Confidence Rankings of Current Thrips and IYSV Management Tactics

Response	**Total (%)**
Very confident in the effectiveness of current strategies	29
Somewhat confident they are effective	58
Not confident they are effective	8
Don't know	5

Nault, 2022). Though it was not directly related to IPM, we wanted to learn more about willingness to adopt innovative practices in managing onion crops to work toward the goal of improved profitability, so we asked growers in New York about their willingness to reduce fertilizer use.

Results are presented in Table 7 and indicate a high level of confidence in the research conducted in New York. The majority, 65% of respondents, were either willing or very willing to reduce the use of fertilizer as part of their overall management strategy. Another 26% of respondents reported being somewhat willing to reduce fertilizer use as part of their onion management strategy. Only 4% of respondents reported being unwilling to reduce fertilizer use as part of their management strategy, and 4% of respondents were unable to respond due to their region or to not knowing.

GENERAL PERCEPTIONS OF IPM AND MANAGEMENT DECISION-MAKING

We had a desire to improve understanding of general perceptions of IPM and the management decision-making process. One area that warranted consideration was how the design of Extension/research projects could impact growers' confidence in adopting IPM-based practices. We provided a list of activities and types of demonstrations relating to IPM and asked growers to rank the level of impact each practice had on increasing their confidence in the adoption of IPM. Results are presented in Table 8. Pest monitoring assistance provided by Extension personnel and demonstration of IPM practices on a commercial scale were ranked by the greatest percentage of respondents as having a very high impact on confidence. On-farm demonstrations and strip trials were also ranked very high by more than one-third of respondents. Use of small plots on university farms ranked lower on the impact scale when compared with larger-scale designs and collaborative efforts between university Extension and growers.

To improve understanding of grower perceptions of the most important factors associated with pest management decision-making, we provided a list of six factors for consideration and asked growers to rank each factor by level of importance. Respondents provided a clear indication of the most important factors affecting the management decision-making process. As depicted in Table 9, the risk of crop loss commanded the greatest attention and was ranked as very important by 82% of respondents. A high percentage of respondents, 49%, also ranked the cost of crop protection products as very important. Commodity price played a key role in the pest management decision-making process, with 41% of respondents ranking the factor as very important.

We sought to improve our understanding of grower perceptions of the most valuable tools, aids, and practices to improve the adoption of IPM-based management tactics. Growers were asked to indicate the degree to which they agreed with each tool or the practice's impact on the adoption of IPM. Results are presented in Table 10. Real-time access to field diagnostic tools via mobile devices received the strongest level of agreement. About 49% of respondents indicated they strongly agreed that development and access to this technology would increase IPM adoption. The practice with the next highest impact involved proving the efficacy of alternatives to traditional pest management.

To improve understanding of the decision to apply insecticides, we asked participants to indicate the level of importance of eight different factors that influence the decision to spray. Results are presented in Table 11. The factor ranked as being very important in influencing the decision to apply insecticides by the greatest percentage of respondents was past experience with a pest. About 59% of respondents indicated previous experience with a pest as a very important factor influencing the decision to spray. Economic thresholds, the first sign of a pest, and the advice of Extension personnel were also ranked as very important influences on the decision to apply insecticides by 38%, 33%, and 33% of respondents, respectively.

Table 7. Willingness to Reduce Fertilizer Use in New York Onions

Response	Total (%)
Very willing	22
Willing	43
Somewhat willing	26
Unwilling	4
Not a concern in my region/ Don't know	4

CONCLUSIONS

Onion thrips/IYSV was ranked as a high-risk problem by 87% of respondents, justifying continued investment in the development of innovative tactics for effective management of these pests. The perception of lower risk from white rot is likely attributable to the geographic distribution of survey participants and commitment to regulatory efforts designed to prevent the introduction of the pathogen in unaffected areas. Even though the level of perceived risk was lower for white rot than for onion thrips and IYSV, all major onion-growing regions remain vulnerable to white rot, justifying the continued investment to improve understanding of management and epidemiology of the disease.

Participants in our survey were significantly younger than the average age of farm producers reported by the USDA. Even though our sample represented a younger demographic, all participants rejected social media as a source

Table 8. General Perceptions of Demonstrations and Activities Affecting Confidence in IPM Adoption

Demonstration type/activity	Very high impact	High impact	Some impact	Low impact	Very low impact	No response
Pest monitoring assistance provided by university Extension personnel	38%	41%	18%	0%	3%	0%
Development of on-farm demonstrations	36%	36%	23%	3%	3%	0%
Demonstration of IPM practices on a commercial scale	38%	38%	23%	0%	0%	0%
Demonstration of IPM practices in strip trials conducted in collaboration with commercial growers	31%	51%	13%	3%	3%	0%
Demonstration of IPM practices conducted on small plots on university farms	15%	31%	41%	8%	3%	3%

Table 9. General Perceptions of Factors Affecting Pest Management Decisions

Factor	Very important	Important	Not important or unimportant	Unimportant	Very unimportant
Risk of crop loss	82%	13%	0%	0%	5%
Commodity price	41%	44%	8%	3%	5%
Availability of IPM consulting	31%	59%	5%	3%	3%
Cost of IPM consulting	18%	49%	23%	5%	5%
Cost of crop protection products	49%	41%	8%	3%	0%
The opinion of other farmers and community members	18%	54%	23%	3%	3%

Table 10. General Perceptions of Tools, Aids, and Information to Assist in IPM Adoption

Factor	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Increased access to decision-support tools will improve adoption of IPM practices	38%	54%	8%	0%	0%
Real-time access to field diagnostic tools (via mobile devices) will improve adoption of IPM	49%	49%	3%	0%	0%
Proving the efficacy of alternatives to traditional pest management will improve adoption of IPM practices	41%	56%	3%	0%	0%
Improving access to and understanding of biologically based pest management tools will improve adoption of IPM practices	28%	51%	21%	0%	0%
Improving access to and understanding of economic thresholds will improve adoption of IPM practices	36%	49%	10%	5%	0%

Table 11. General Perceptions of Factors that Influence the Decision to Apply Insecticides

Factor	Very important	Important	Neither important nor unimportant	Unimportant	Very Unimportant
Economic thresholds	38%	33%	21%	8%	0%
Salesperson recommendations	13%	38%	31%	15%	3%
When other growers spray	3%	23%	54%	21%	0%
Past experience with a pest	59%	38%	3%	0%	0%
First sign of a pest	33%	56%	10%	0%	0%
Maintaining a calendar-based spray program/regular spray schedule	21%	41%	26%	13%	0%
Advice of Extension personnel	33%	62%	5%	0%	0%
Advice of private pest management consultants	15%	51%	13%	8%	3%

of information for pest management decision-making. Most respondents favored science-based publications, workshops, and interactions with trusted Extension professionals as their primary sources of information. The results of our survey suggest that growers value the personalized connections established with Extension professionals, whose unbiased information and guidance they trust more for making management decisions than information coming from unknown sources through social media. However, the lack of enthusiasm for social media should not be misconstrued as a rejection of technology to inform decision-making. Participants in our survey indicated a strong preference for applied technology within the pest management decision-making process. Longer-term goals of IPM professionals should include procuring funding to support development of real-time field diagnostic tools compatible with mobile devices.

Survey results astutely characterized the difficult pest management decision-making process growers face. The fear of crop loss must be reconciled with the expense of crop protection products and their application. A failure to execute managerial tactics when necessary can negatively impact returns due to crop loss. Conversely, the execution of unnecessary pesticide applications can also push returns below their potential when compared to more judicious management tactics. In the long run, imprudent use of crop protection products can also jeopardize the viability of a limited number of management alternatives.

Growers in our survey reported an open-minded approach to pest management, indicating a willingness to try new tactics. They also reported a high degree of confidence in Extension, as measured by a 92% satisfaction rate. However, if a change is to occur, Extension professionals must increase grower-level confidence that IPM-based practices will be as effective as current techniques.

Our analysis provides clear direction for practitioners seeking high-impact practices to assist in improving the adoption of IPM. Even though university farms play a critical role in development and early evaluation of new IPM practices, practitioners must ultimately demonstrate the efficacy of IPM on a commercial scale to increase confidence in the practice and facilitate large scale adoption by commercial growers. There is also a need to steward cooperative efforts among IPM practitioners and growers to bridge the gap between the university and the commercial farming sector. The strongest need for collaboration, as identified by our sample, was pest-monitoring assistance. We believe that mutually beneficial exchanges of knowledge can occur when commercial growers and IPM practitioners work together. Results from our analysis coincide with the findings of other researchers, indicating a need to facilitate increased collaboration among stakeholders through collaborative, public-private partnerships (Markell et. al., 2020). If such efforts are made, practitioners can help improve the ability to demonstrate the efficacy of IPM on a commercial scale, increasing confidence in IPM-based practices.

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