SAES-422 Multistate Research Activity Accomplishments Report

Project No. and Title: W2008 Biology and Management of *Iris yellow spot virus* (IYSV), Other Diseases and Thrips in Onions

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Accomplishments (limited to 30,000 characters)

Objective 1. Evaluate onion germplasm for greater levels of tolerance to *Iris yellow spot virus* (IYSV), other pathogens and thrips.

Colorado (H. Schwartz, S. Szostek, W. Cranshaw, M. Bartolo, T. Gourd, B. Hammon) – During 2013, the Colorado team reevaluated the following germplasm with significantly greater plant vigor after season-long exposure to thrips at Fort Collins: selections from MSU611AxMSU611-1B 22665, 22684, 22720 and 22724. Bulbs have been sent to Mike Havey for potential use in genetic and molecular marker studies with IYSV and thrips resistance; and include PI 261591, 264320, 264648, 274780, 288903, 288909, 546096, 546101, 546106, 546140, 546188, 546192, and 546201.

New Mexico (C. Cramer) - Eighty-eight onion breeding lines selected for reduced IYSV disease symptom expression, 7 plant introduction (PI) accessions from the U.S. germplasm collection, 8 experimental breeding lines from the New Mexico State University (NMSU) breeding program, and 3 commercial cultivars were evaluated for the number of thrips per plant and IYSV disease symptoms. Adult and juvenile onion thrips number per plant was highest at 13 and 16 weeks post transplanting. Among those breeding lines selected for reduced IYSV symptom expression, plants of 33, 37, and 25 lines possessed fewer thrips at 10, 13, and 16 weeks after transplanting, respectively, than plants of the susceptible checks, ‘Rumba’ and ‘Vaquero’. For those lines that were selected from PI 172703, plants of seven second generation lines had fewer thrips than plants of PI 172703 when thrips were counted at 10 weeks. At 13 weeks, plants of nine second generation lines has fewer thrips per plant than plants of PI 172703. For those lines that were selected from PI 546140, plants of NMSU 12-295 had fewer thrips than plants of PI 546140 when thrips were counted at 10 weeks.

Among those breeding lines selected for reduced IYSV symptom expression, plants of 13 lines exhibited less severe IYSV disease symptoms than plants of the susceptible checks, ‘Rumba’ and ‘Vaquero’ at 13 and 16 weeks after transplanting. At 13 and 16 weeks, plants of second generation lines, NMSU 12-335 and 12-342, exhibited less severe disease symptoms than plants of their parental lines, NMSU 07-32-2 and 07-56-2, respectively. At 13 weeks, plants of NMSU 12-236 exhibited a lower disease severity than plants of its parental line, NMSU 07-52-1. At 16 weeks, plants of second generation lines, NMSU 12-239 and 12-243, exhibited less severe disease symptoms than plants of their parental line, NMSU 07-53-1. In addition, plants of NMSU 12-285 exhibited less severe disease symptoms than plants of its parental line, PI 289689. At 19 weeks, plants of NMSU 12-335 and 12-243 exhibited less severe disease symptoms than plants of their parental lines, NMSU 07-32-2 and 07-53-1.

Eleven selected lines exhibited a lower IYSV disease incidence than the susceptible checks, ‘Rumba’ and ‘Vaquero’ at 13 weeks after transplanting. Selected lines, NMSU 12-236 and 12-335, exhibited a lower disease incidence percentage than their parental lines, NMSU 07-52-1 and

07-32-2, respectively. By 16 weeks, disease incidence had reached 100% for all entries. Seed of numerous first generation selection lines was produced this year so that seed could be distributed to the onion seed industry for evaluation.

New York (B. A. Nault, S. V. Beer and C. A. Hoepting) - An onion thrips management program that combines a partially thrips-resistant cultivar (cv. 'Advantage') and insecticide applications timed using action thresholds was evaluated in a commercial onion field in 2013. Season total densities of onion thrips in untreated plots were similar between 'Advantage' and the thrips-susceptible cultivar, 'Santana'. Onion thrips were controlled effectively in both 'Advantage' and 'Santana' plantings following either a weekly insecticide spray program or an action threshold program. However, fewer insecticide applications were applied in the action threshold program compared with the weekly spray program, especially for 'Advantage'. Marketable bulb yield for 'Advantage' was similar between the insecticide treatments and untreated control, indicating that despite significant differences in thrips densities between treated and untreated planting, this cultivar exhibits tolerance to thrips. In contrast for 'Santana', marketable yield in untreated plots was significantly lower than in treated ones.

Oregon (S. Reitz, C. Shock, E. Feibert, and M. Saunders) - In 2013 four early-season yellow varieties were planted in March and were harvested and graded in mid-August. Forty-nine full-season varieties (39 yellow, 3 red, and 7 white) were planted in March, harvested in September 2013, and graded out of storage in January 2014. Onions in each plot of the full-season trial were evaluated for maturity and for severity of symptoms of IYSV. Each plot was given a subjective rating on a scale of 0 to 5 of increasing severity of IYSV symptoms. During grading, bulbs were separated according to quality: bulbs without blemishes (No. 1s), split bulbs (No. 2s), neck rot (bulbs infected with *Botrytis allii* in the neck or side), plate rot (bulbs infected with *Fusarium oxysporum*), and black mold (bulbs infected with *Aspergillus niger*). Varieties varied in Botrytis, plate rot, black mold, but not IYSV which was very low in field trials in 2013.

Utah (D. Drost) - Twenty-nine commercially available Spanish onion cultivars were assessed for productivity, maturity and rated for IYSV. Symptom expression of IYSV in 2013 was very low; however, all varieties evaluated showed visual evidence of IYSV under field conditions. IYSV had little impact on onion bulb yield. Further evaluation of storage materials will occur in February 2014 to assess losses. Work on correlations between IYSV incidence and storage needs further evaluation.

Objective 2. Investigate thrips biology and IYSV epidemiology to improve management strategies.

Colorado (H. Schwartz, S. Szostek, W. Cranshaw, M. Bartolo, T. Gourd, B. Hammon) – Research evaluations performed this year included a thrips and IYSV assessment. Thrips populations were counted on July 24 at the Sakata Farm near Brighton and August 7 at the CSU ARDEC Farm near Fort Collins, CO. The Sakata Farm trial averaged 3.3 thrips and the CSU ARDEC Farm averaged 12 thrips per onion plant. With only moderate levels of thrips, we did, however, experience a 99% plant infection rate of IYSV at both locations. The IYSV assessments of incidence and severity were taken on September 30 at the Sakata location and on September 25 at the CSU ARDEC location. The Sakata location experienced a 1.7 severity level and the CSU ARDEC location had a 3.8 severity level (0-4 scale with 0 = no damage and 4 = having over 25 medium to large lesions per leaf). This could also explain why the CSU ARDEC location did not see adequate sizing up of the onion bulbs.

Sticky traps showed that thrips were active until mid-December (2012 and 2013) when the average temperature fell below 0°C. In 2012, activity resumed in early March. IYSV was detected by RT-PCR in live adult and larval thrips recovered from several field sources during the winters of 2010-2011, 2011-2012, and 2012-2013. Few live thrips were found after the onset of decay in onion cull piles. Live thrips were easily recovered from winter annual species. Five of these weed species have been grown from seed in the greenhouse and exposed to viruliferous thrips to further elucidate their role as green bridges. Of the five, IYSV has been detected in *Tragopogon dubious* (western salsify) and thrips larvae reared on this plant. Results indicate winter annuals play a role in onion thrips and IYSV over-winter survival, providing inoculum the next growing season.

More than 3000 plants grown from seed have been tested for IYSV by DAS-ELISA; all the plants that remained thrips-free (2,762 plants) were negative for IYSV. DAS-ELISA tests of germinated seed did detect IYSV in the seed of some individuals. This seed lot was comprised of seeds collected from 59 individual IYSV-infected field-grown plants representing seven varieties of red, yellow, and white onions. Because Tospoviruses are not known to be seed transmitted, 50 seeds from 12 individual plants (three individuals from each of the varieties Granero, Salsa, Red Defender, and Pentium) are germinating and the resulting shoots of 7 of these 12 plants are being separated from the seed coat and tested for IYSV by RT-PCR. IYSV has been detected in the seed coats of Pentium and Red Defender individuals, while the corresponding shoots were negative. The two Granero individuals tested have been negative. Because the seed coat does not always separate cleanly from the endosperm the possibility that IYSV is present in the endosperm cannot be discounted, although we feel that this is highly unlikely.

Idaho (S.K. Mohan) - Four sentinel plots in commercial onion fields in the Treasure Valley were monitored periodically from May to August for incidence and severity of IYSV and infestation levels of onion thrips. Samples collected every two weeks were evaluated for any disease symptoms (mainly for IYSV) and pests (mainly counting thrips populations). IYSV symptoms were first observed in the first week of July but incidence was very low (less than 1%) until the second week of August. After that point the incidence increasing up to 20% plants with symptoms in one of the plots by the third week of August. Generally low levels of thrips (2 to 7/plant) were observed at the end of May, increasing with time and reaching high levels (up to a maximum of 70/plant) by August. Thrips samples collected were sent to Colorado State

University for identification of the thrips species involved and to determine the percent carrying IYSV. No significant incidence of any other pest or disease was observed.

New York (B. A. Nault, S. V. Beer and C. A. Hoepting) - More adult onion thrips were captured dispersing in onion fields in August than in June. Thrips also tended to fly more around dusk than any other period during the day. Most of the thrips dispersing in onion fields were captured below 6ft, suggesting that most engage in trivial flight or plant to plant movement. However, onion thrips were captured above 6ft including some as high as 300ft above onion fields. In August, a significant percentage of these thrips tested positive for IYSV, including some captured at 300ft. Results indicate that both onion thrips and IYSV have the potential to spread long distances.

There were many commercial onion fields in NY that were transplanted with onion plants initially grown in Arizona. Two of these fields, located 10 miles northwest of Elba where the nearest large commercial onion production occurs, became severely infected with IYSV. No transplanted fields in the Elba muck onion production area suffered serious symptoms of IYSV. More research is needed to determine if imported onion plants from Arizona are infected with IYSV before arriving in New York.

Co-applications of insecticides (Agri-Mek, Movento and Radiant) with mineral oils (PureSpray Green and JMS Stylet oil) were equally effective for managing onion thrips as these insecticides co-applied with traditional penetrating surfactants like Induce and MSO.

Season-long management of onion thrips continues to be most effective using a series of products beginning with Movento (2 applications) followed by Agri-Mek (2 applications), Lannate (2 applications) and Radiant (2 applications). Exirel should be available for many onion growing areas in 2014 and will be best applied after Movento; Exirel does not work as well late in the season. Use of action thresholds (1 larva per leaf) in spray programs in New York has consistently reduced the number of insecticide applications needed to manage thrips from 17 to 58%.

Oregon (S. Reitz, C. Shock, E. Feibert, and M. Saunders) - A field trial testing 20 insecticide regimes was established in 2013. Insecticides were applied to the foliage weekly for 8 weeks from late-May through mid-July. Thrips were monitored by counting thrips on 15 plants per plot. Plants were subjectively rated for thrips feeding damage and severity of IYSV infection. Onions were harvested and graded to determine yield. Thrips pressure was high throughout the season but there were significant differences among the insecticide regimes in terms of thrips and IYSV management and yield. Yield was significantly related to onion thrips pressure, with programs that maintained the best management of thrips during the middle of the season (late June-early July) tending to have the highest yields and greater proportions of colossal and supercolossal sized onions.

A program to monitor for insecticide resistance in onion thrips was started in 2013. Feral thrips were collected from commercial fields and then exposed to insecticide treated onion foliage under laboratory conditions. Mortality was assessed after 24 and 48 hours of exposure. Results indicate that onion thrips populations remain highly susceptible to four commonly used insecticides, Agri-Mek, Movento, Lannate and Radiant.

Utah (D. Alston, D. Drost and C. Nischwitz) - Sentinel plots/survey sites were monitored in the Davis, Weber, and Box Elder County production onion areas in Utah in 2013. Fields were evaluated from June until September for thrips, other insects, and IYSV. Bi-weekly reports were submitted, along with weather summary, Sentinel Plot reports, growth observations, and other insect and disease comments.

Sustainable onion production occurs when inputs (planting dates, nutrients, water), onion thrips, and IYSV are properly managed. Onion growers in Utah report improved thrips management and reduced IYSV severity through alternative crop rotations and improved nitrogen management. Growers are using USU research findings to alter their production practices thus reducing thrips numbers and IYSV incidence with minimal impact on onion productivity. Growers in New York, Washington, and Idaho are also using these tactics to better manage insects and diseases.

Field crops and weeds growing next to onion fields were sampled for IYSV and thrips during the 2013 onion season (May-Sept) and tested for the presence of IYSV. Finding alternative IYSV hosts in the farm landscape surrounding onion fields allows farmer the opportunity to treat or remove these plants thus reducing the amount and source of IYSV inoculum. Results show that alfalfa, corn, prickly lettuce, common mallow, and field bindweed tested positive for IYSV. Crop fields (corn, wheat, alfalfa) adjacent to onion fields harbored onion thrips in varying amounts and most were good reproductive hosts for thrips.

Washington (H. R. Pappu, T. Waters, C. Wohleb, B. K. Schroeder, and L. J. du Toit) - Field plots of onion (cv. ‘Sabroso’ Nunhems) were established at the WSU Research Farm in Pasco, WA and grown using drip irrigation and standard grower practices for agronomic and pest management inputs excluding thrips treatments. Plots (7.5 feet wide and 30 feet long) were established in a random complete block design with four replications. Applications (except where specified) were made with a CO_2 pressurized back pack sprayer applying 30 gallons of water carrier per acre at 35 psi. Efficacy was evaluated four or five days after applications by counting the number of immature and adult thrips per plant on 10 individual plants per plot in the field. All data for each sample date were analyzed by ANOVA and treatment means were compared to thrips population means from non-treated control plots in pairwise *t*-tests. At the end of the growing season, onion yield and size were evaluated for comparison among treatments.

Using insecticides that are effective at controlling thrips increases yield and size class of dry bulb onions. Radiant and Lannate were found to be the most effective products while Movento, Benevia/Exirel, Torac and AgriMek provided good suppression of onion thrips. All of the sequential applications tested provided excellent season long control of thrips and if adopted by commercial growers could increase economic returns. Weekly applications are not always needed as shown on the sequences where applications were skipped either early during the season or at the middle of the season. It is important for growers to consider the mode of action of the different chemistries when integrating them into their control programs. Chemigation proved to be an effective way to apply Lannate, and Radiant. There is evidence that Movento, Torac, and Exirel may be effective by chemigation, but further work should be performed for confirmation.

3. Investigate the biology, ecology and epidemiology of other pathogens to improve management strategies

Colorado (H. Schwartz, S. Szostek, W. Cranshaw, M. Bartolo, T. Gourd, B. Hammon) – Disease incidence of Pink Root was not decreased by treatments with Serenade or Quadris in a nursery with low disease pressure and cool to moderate temperature conditions early to mid-season.

Xanthomonas leaf blight infection (incidence and severity) was reduced by timely applications of bactericides such as Kocide 3000 and experimentals when compared to the untreated control which sustained 60 percent canopy damage by the end of the season.

Botrytis infection was detected in 2 to 12 percent of transplanted bulbs in storage rot experiments during 2013. Fungicide treatments including Pristine, Priaxor or Merivon combined with good curing practices reduced the 60-day loss from Botrytis in the yellow transplanted onions.

New York (B. A. Nault, S. V. Beer and C. A. Hoepting) - At least four different bacteria can cause rot and render onions unsalable in New York. These include *Burkholderia spp.* (sour skin), *Enterobacter cloacae* (Enterobacter bulb decay), *Pantoea ananatis* (center rot) and *Rahnella spp.* We developed two distinct methods to identify the bacteria associated with cull onions. In one, a method of analyzing a portion of a specific gene was developed. That particular gene is grossly similar in all bacteria, but it is distinct in all onion-associated bacteria that we examined. Using a special means of analyzing that gene portion allowed for identification of a dozen different bacteria (pathogens and non-pathogens) associated with cull onions. For the four specific bacterial pathogens mentioned above, we designed, developed, and tested pairs of primers that can be used in the Polymerase Chain Reaction (PCR) to detect the presence of one or more of the stated important bacterial pathogens. The method is applicable to the detection of bacteria in cull onions, onions growing in the field, water collected from onion fields and for the soils in which onions have been grown.

Most of the important bacterial pathogens of onion previously had been detected in soils collected from onion fields prior to or soon after onions were planted in muck fields in the spring. Recently, several of the bacteria of interest were detected in some, but not all, the water samples collected from the vicinity of onion fields, including drainage ditches, creeks, cisterns and shallow wells.

We evaluated the susceptibility of several onion cultivars to leaf lesions induced by inoculation with *Pantoea ananatis.* Significant differences were noted. However, when mature bulbs of several of the same cultivars were inoculated with the pathogen, no differences in the development of bulb symptoms were noted. Thus, further work is needed to develop a reliable assay for the relative susceptibility of different genotypes to bacterial pathogens.

In 2013, we organized extensive trials of sprays of Actigard®, a resistance-inducing chemical, applied by spraying during the growing season, on resulting bacterial decay. Ten trials were carried out in Orange County and on the Elba Muck (Orleans and Genesee Counties). Four or five sprays were applied in each 2- to 5-acre field. In the control plots, no resistance inducer was applied, but all other aspects of crop management were similar. At harvest, three to five replicate samples of 100 bulbs each were hand-harvested and bagged. After typical storage for 6 to 12 weeks, each bulb was examined and rated for the presence of bacterial decay; most were cut to reveal any evidence of decay. Results indicated no evidence that the sprays of Actigard® resulted in differences in the percentage of bacterial decay in any of the 10 trials.

Onion foliage diseases were also studied in NY. An on-farm, small-plot comparison of fungicides for control of onion leaf diseases was conducted, which included 21 treatments. Best material for managing Botrytis leaf blight was Bravo, which was closely followed by Merivon. Best material for managing Purple Blotch was Scala. Best materials for control of Stemphylium leaf blight were Luna Tranquility, Merivon and Fontelis followed by Pristine and Inspire Super. These results will be used to make research-based fungicide recommendations that will ensure that all leaf diseases of onions are managed effectively.

A curious situation occurred during the 2013 growing season in NY where excessive leaf dieback and onions "dying standing up" was caused by Stemphylium leaf blight (SLB). Normally, SLB occurs as a secondary pathogen in onions invading plant tissue that is already compromised. What caused this disease to move from its usual backseat position as a secondary pathogen to the forefront as an aggressive pathogen is unknown. Based on recent history in Ontario, Canada with SLB, it is expected that SLB will be a regular contender in NY onion fields. Fortunately, Hoepting was able to identify some promising new fungicides to combat SLB in her 2013 on-farm, small-plot onion fungicide trial. Based on her results, it is expected that when fungicides with excellent activity against SLB are incorporated into the onion fungicide spray program, NY onion growers will never experience such severe SLB again.

Adjuvants co-applied with insecticides were evaluated for their impact on fungal and bacterial diseases. Replacing penetrating surfactants like Induce and MSO with mineral oils (PureSpray Green and JMS Stylet oil) for managing onion thrips had no effect on the incidence of Botrytis leaf blight, purple blotch or bacterial rot diseases. However, significantly higher levels of Botrytis leaf blight occurred in treatments where onion thrips were controlled compared to those where they were not.

Oregon (S. Reitz, C. Shock, E. Feibert, and M. Saunders) - Studies were initiated to understand the movement of *E. coli* in water and soil and *E. coli* survival on onion bulbs. Onions of all treatments of all experiments discussed above were evaluated for plate rot, Botrytis, and black mold.

Pennsylvania (B. Gugino) - In Pennsylvania in 2011 and 2012, replicated on-farm survey plots were established on 28 and 26 farms, respectively to identify potential sources of inoculum as well as production factors related to harvest disease incidence. The extensive dataset generated continues to be a source of new information. A total of 235 bacterial isolates were recovered from 192 samples of the four most common weed species (crabgrass, redroot pigweed, purslane and lambsquarters) collected from commercial onion fields in 2011. Nearly 60% of the culturable bacteria isolated were potential pathogens of onion. *Pseudomonas marginalis* was commonly cultured from all types of weeds, while *Pantoea agglomerans* was commonly associated with crabgrass and purslane. *Pectobacterium carotovorum* was common only to redroot pigweed. Based on pathogenicity tests, all the bacterial isolates from lambsquarters were able to cause onion bulb rots while other weeds were found to have mixed populations of pathogenic and nonpathogenic bacteria on their surfaces. By sampling common weeds near onion fields in 2011, it was shown that weeds are a potential source of bacterial inoculum that causes diseases in onion bulbs.

A rep-PCR method was developed to track bacterial strains within the same bacterial species. This will enable us to further link bacterial isolates collected from the surface of transplants, weeds, and soil from the on-farm survey plots to those isolated from symptomatic onion bulb tissue at harvest or after storage and further facilitate the development of management strategies to reduce these potential sources of bacterial inoculum.

At-planting and at-harvest soil nitrogen, leaf and bulb tissue nitrogen, soil temperature and other factors were analyzed in a multivariate linear regression model. A strong negative relationship between leaf tissue nitrogen at midseason and total harvest losses was suggested, while a positive relationship was also identified between pre-harvest soil temperatures and bacterial disease incidence. These results relate the importance of reducing soil temperatures through use of alternative plastic mulches, ensuring adequate soil fertility early in the season and taking measures to reduce the impact of inoculum sources in the production system.

Two field trials were conducted to evaluate the effects of inoculum pressure and onion maturity at harvest on harvest and post-harvest losses due to bacterial disease. The goal was to provide growers with additional information on the relationship between the timing of harvest and bacterial disease losses post-harvest so they can make informed decisions about when to harvest fields under pressure from bacterial diseases. Seasonal observations have indicated that environmental conditions around the time of bulbing greatly influence disease development. Harvesting too early significantly reduces the proportion of jumbo and colossal sized bulbs but delaying harvest in fields with higher foliar disease ratings could lead to significant at-harvest losses of greater than 30%. Data from these initial field trials suggest that foliar disease ratings between 3 (one half of one leaf symptomatic) and 4 (one entire leaf bleached and wilting) on a 1 to 7 point scale may be a critical threshold to help growers determine when to harvest onions to maximize yield while minimizing bacterial disease losses at harvest.

Washington (H. R. Pappu, T. Waters, C. Wohleb, B. K. Schroeder, and L. J. du Toit) - An onion pink root trial was completed near Pasco, WA to evaluate the potential for Serenade Soil to reduce the impact of this disease. The trial had a very severe outbreak of pink root, with 100% incidence of infection and severity averaging 72% (% of roots with pink root symptoms) in inoculated plots and 57% in non-inoculated plots. A single application (banded over the bed) of Serenade Soil at planting at 4 qt/acre, or three applications at 2 qt/acre (at planting, 3 weeks and 6 weeks after planting) did not reduce severity of pink root compared to the control plots. Average bulb weight was not affected by the Serenade Soil treatments either. The results indicate Serenade Soil may not help reduce the impact of pink root in onion bulb crops.

In a greenhouse trial to assess potential beneficial effects of mycorrhizae in onions at reducing the impact of soilborne pathogens of onion, onion plants grown in soil inoculated with *Rhizoctonia solani* AG-8 averaged a height of 6 cm compared to 15 cm for plants in non-inoculated control soil (>50% reduction in plant height caused by *R. solani*). When soil was infested with a commercial mycorrhizal inoculum (BioTerra Plus from Plant Health LLC), plant height averaged 20 cm, which was significantly greater than the height of seedlings in the control soil, and demonstrated a beneficial effect of mycorrhizae even in the absence of a soilborne pathogen. When onions were grown in soil inoculated with both *R. solani* AG-8 and the mycorrhizae, plant height averaged 18 cm, which was significantly taller than plants in the control plots, and not significantly different than plant height in soil infested with mycorrhizae alone. Similar results were obtained with the repeat trial. The results suggest that inoculation of soil with mycorrhizae may not only enhance onion growth, but also provide some protection against adverse effects of the soilborne pathogen *R. solani*. Similar experiments are planned with onion pink root. In a preliminary survey of conventional and certified organic onion bulb crops in the Columbia Basin of central Washington in 2013, mycorrhizae were detected in onion roots in all of these crops, although to different degrees of root colonization. The survey indicated that mycorrhizae can establish readily in soils in which onion bulb crops are grown in the Columbia Basin, even following soil fumigation which is widely practiced in this region (an estimated 90% of fields in which onion bulb crops are grown in the Columbia Basin are fumigated every 2-3 years). Large-scale, grower-cooperator mycorrhizae inoculation trials are planned for 2014.

A DNA macroarray was developed to detect the onion bulb rot fungi *Aspergillus niger*, *Botrytis aclada*, *B. allii*, *B. byssoidea*, *B. cinerea*, *Fusarium oxysporum*, *F. proliferatum*, *Kluyveromyces marxianus* var. *marxianus* as well as several species of *Penicillium*. The technology uses pathogen-specific oligonucleotides bound to a membrane. The membrane is then used to hybridize DNA that has been amplified by polymerase chain reaction (PCR) from plant samples, enabling detection of multiple target organisms at the same time. A macroarray for detection and identification of the major onion bulb rot pathogens would be a valuable tool to detect and differentiate causal organisms associated with bulb rots in storage. The fungal DNA macroarray is able to detect and differentiate the fungal pathogens when the DNA is obtained from pure cultures. This was accomplished by sequencing the ITS region obtained from fungal isolates across the genera listed above. These sequences were aligned which revealed genus-specific and species-specific oligos. The oligos were modified with a 5' tail of nucleotides to enhance the specificity and improve binding of the oligos to the nylon membrane support. The fungal DNA macroarray is able to specifically detect and differentiate the fungal bulb rot pathogens. The specificity of the fungal DNA macroarray was evaluated against nonpathogenic fungi commonly found in association with onion bulbs as well as fungal species closely related to the bulb rot fungi. The fungal DNA macroarray is quite sensitive with detection of fungal pathogens possible with attogram levels of pathogen DNA present in the original PCR reaction.

The development of the bacterial DNA macroarray focused on the 12 bacteria capable of causing onion bulb rot in storage including: *Burkholderia cepacia, B. gladioli, Pantoea agglomerans, P. allii, P. ananatis, Pectobacterium carotovorum, Enterobacter cloacae, Pseudomonas marginalis, Erwinia rhapontici, Dickeya dadantii,* and *Pseudomonas aeruginosa*. The development of the bacterial DNA macroarray included amplification of a region of the 23S rDNA which was sequenced and analyzed to identify unique nucleotides for bacterial pathogens and design oligonucleotides specific for each organism. The oligos contained more than one polymorphism and range from 17- 30 nucleotides in length. The bacterial oligos were more specific and more sensitive if they were present as a dimer with a nucleotide spacer in between. Efforts have focused on optimizing the detection conditions to eliminate cross reaction among the target bacteria listed above as well as non-target organisms associated with onion bulbs. Currently, there is some cross reaction among the Pseudomonas strains on the bacterial DNA macroarray. It is not clear why this is occurring and it is being investigated. The sensitivity of the bacterial DNA macroarray has not been determined. The fungal DNA macroarray was able to detect the presence of fungal pathogens present in asymptomatic onion bulbs, suggesting that it could be used to predict the risk of storage rots. It has not been determined if the bacterial DNA macroarray can detect bacterial plant pathogens present in asymptomatic onion bulbs as latent infections.

A second genome of *Enterobacter cloacae*, cause of Enterobacter bulb decay, was sequenced (manuscript in press). In addition, the genetic diversity *E. cloacae* isolates was demonstrated by a multi locus sequence analysis (MLSA) that there is strong phylogenetic support for the organisms isolated from different hosts to be in different clades. In addition, it appears that the isolates obtained from onion bulbs group with reference strains of another species, suggesting that these isolates are misidentified.

Objective 4. Facilitate interaction and information transfer between W2008 participants, the onion industry and other stakeholders.

Oregon (S. Reitz, C. Shock, E. Feibert, and M. Saunders) - The project has continued to effectively transfer information pertinent to IYSV and thrips biology to growers, other onion industry parties, and the public through numerous meetings, field days, publications, and the internet. Results have been effectively communicated by grower and fieldman participation in the project planning and evaluation of results, field days for growers (July 10, and August 26, 2013), tour for the FDA (August 12, 2013), grower meetings (February 5, 2013), internet web sites, and results being reported in Onion World and the Capitol Press.

Pennsylvania (B. Gugino) - In Pennsylvania research results were disseminated at several vegetable grower meetings/conferences including the 2013 Mid-Atlantic Fruit and Vegetable Convention and Lancaster Onion Co-op meeting as well as during the 4th Annual Discovery Day at the Southeast Agricultural Research and Education Center which is geared towards the media and legislators who are interested in learning more about agricultural research that directly impacts the Commonwealth. On a national level, results were presented by Emily E. Pfeufer, Ph.D. candidate, at the 2013 American Phytopathological Society meeting in Austin, TX in August 2013. Results were also disseminated throughout the season through one-on-one with the growers collaborating in the intensive field survey project. We continued to disseminate the Diagnostic Pocket Series as well as the Onion Health Management and Production bulletin to interested growers and other stakeholders.

Utah (D. Alston, D. Drost and C. Nischwitz) - Participation in the regular Onion ipmPIPE project conference calls throughout the year. Sentinel plots/survey sites (26 sites) were monitored in the Davis, Weber, and Box Elder County production onion areas in Utah by our team. Fields were evaluated from early June till early September for thrips, other insects, and IYSV. Drost submitted reports along with regional weather conditions, Sentinel Plot reports, growth observations, and other insect and disease comments. Reported on varietal research provided to Utah growers (52 attendees) at the February 2013 winter onion meetings. Alston talked about ipmPIPE project, and Nischwitz provided growers with IYSV information. Growers (42) attending the summer onion field tour (Aug 2013) learned about sustainable onion production, and were provided with details of impPIPE information. Utah onion association met twice (Apr, Nov) where they were provided with national update of ipmPIPE. Drost gave two presentations at the W2008 Annual Meeting describing Utah based research findings.

Impacts

Outputs of this work posted on web sites and presented at various meetings will be used by the Colorado and national onion industries, growers, seed company breeders and pathologists, and integrated pest management specialists to select more effective management strategies including the promotion of varieties that are less susceptible to damage by thrips and the virus.

Germplasm was identified that possessed a reduced number of thrips per plant than most entries. Entries were identified that exhibited less severe IYS disease symptoms than most entries. Selection for reduced thrips number and IYS disease severity appears to be effective. Additional cycles of selection may be beneficial for increasing tolerance to thrips and/or IYS.

As a result of growers' using Cornell-recommended IPM program for thrips (combines spray thresholds, resistance management practices, proper adjuvants, avoiding non-compatible tank mixes with fungicides, and reduced nitrogen fertilizer inputs), effective management of onion thrips was achieved with 40 to 57% fewer insecticide applications per field compared with standard weekly spray program. Potentially, this translates into an average 50% reduction in annual insecticide use statewide and a savings of $1.1 million in insecticide costs, not including savings in fertilizer costs. Use of the Cornell-recommended IPM program for managing onion thrips reduced Environmental Impact Quotient (EIQ) points by a staggering 94% from 2005 when growers were unable to effectively control onion thrips with an arsenal of insecticides that were environmentally not friendly.

Results from our work were presented at various meetings throughout New York and beyond and will be used by the national onion industry, growers, seed company breeders and pathologists, and integrated pest management specialists to select more effective insect, virus and disease management strategies.

In Oregon, findings from this research has been posted on websites, published in newsletters, presented at various meetings, and communicated directly with growers and other industry personnel. This information has led to the adoption of more effective management programs in onion cropping systems in Oregon:
1). More growers are adopting onion varieties with greater tolerance to IYSV.
2). More growers are adopting drip irrigation and maintaining better management of soil moisture. The onions grown with drip irrigation and careful irrigation scheduling tended to have less severe problems with IYSV.
3). Growers continue to improve their use of insecticide rotation programs through the growing season. Research trials have led to the identification of effective season-long insecticide use programs. These programs have enabled growers to successfully manage thrips over a single growing season and reduce the risk of insecticide resistance developing.
4). Due to better knowledge of the transmission of IYSV, fewer growers are planting over-wintering onions. With fewer overwintering onions and better cull onion disposal, growers are breaking the natural green bridge keeping IYSV pressure high from one production year to the next. Some growers continued to suffer IYSV related yield losses due to over-wintering onion bulb or seed fields close to their summer production fields.

In Pennsylvania, an extensive data set on the potential factors associated with onion bacterial diseases has been collected and continued comprehensive analysis of this data set is further elucidating some of the factors most closely associated with onion bacterial diseases. In the meantime, growers are gaining a better understanding about what bacterial pathogens are causing losses at harvest and in storage and making changes in current production practices to reduce losses by modifying soil temperatures through use of alternative plastic mulches or physical manipulation of the plastic at bulbing.

Results of preliminary mycorrhizal survey work were presented at the 2013 WSU Onion Field Day, and published in the popular magazine 'Onion World' in Nov. 2013 (see publications listed below). Grower-cooperator trials in the Columbia Basin with mycorrhizal inoculations are planned for 2014, based on very promising preliminary results demonstrating that inoculation of soil with mycorrhizae can completely prevent expression of onion stunting symptoms caused by *Rhizoctonia solani*.

Similarly, an article on pink root of onion that focused on why pink root was so severe in 2013 in the Columbia Basin of central Washington and north-central Oregon was published in the Dec. 2013 issue of 'Onion World' (see below), based on a presentation given by Lindsey du Toit at the 2013 Pacific Northwest Vegetable Association Annual Convention & Trade Show in Nov. 2013. The article highlighted the biology and management of pink root.

More growers in Utah are using lower nitrogen levels (130-150 lb. N/A) and applying fewer insecticide sprays on onions. Growers report saving $150-200/A on reduced pesticide inputs and by using less N the savings on fertilizer costs is $75-100/A. Lower N use may also provide environmental benefits through less N leaching. We estimate that more than 450 acres of onions in Utah are now being grown using lower N level recommended by Utah State University.

Recent research conducted by Utah State University (2011-2013) continues to show that onions planted after corn in the crop rotational sequence have few thrips than when onions are grown after wheat. This may contribute to lower pesticide usage. In 2013, six growers used this system and approximately 250 acres were grown after corn. We started to monitor onion thrips pressure and study how crops grown adjacent to onion fields influences thrips migration patterns, IYSV and virus harboring plants. We evaluated 26 field sites from 10 growers. This data set is being analyzed and will be reported on in detail elsewhere.

Publications

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Beer, S. V., Asselin, J.-A. E., Bonasera, Zaid, A. M., J. M. and Hoepting, C. A. 2012. Better understanding bacterial onion diseases in New York. Onion World 28: (4) 18-22.

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du Toit, L.J., Derie, M.L., and Waters, T.D. 2014. 2013 Onion pink root Serenade Soil efficacy trial in Pasco, Washington. Research report submitted to Dean Christie, Bayer CropScience, in Feb. 2014. 5 pp.

du Toit, L.J., Poudyal, D.S., Paulitz, T., and Linderman, R. 2013. Preliminary survey for mycorrhizae in organic and conventional onion bulb crops in the Columbia Basin. Pp. 12-13 in: 2013 WSU Onion Cultivar Demonstration and Field Day Handouts. Washington State University, Pullman, WA.

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Knerr, A.J., Humann, J.L., du Toit, L.J., Schroeder, B.K., and Armstrong, C. 2013. Advancement in Molecular Techniques for Rapid Identification of Onion Bulb Rot Pathogens: Development of a Bacterial DNA Macroarray. 2013 WSU Onion Cultivar Demonstration and Field Day Handouts.

Muñoz, R. M., Lerma, M. L., Lunello, P., and Schwartz, H. F. 2013. Iris yellow spot virus in Spain: incidence, epidemiology and yield effect on onion crops. J. of Plant Pathology accepted

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Nault, B. A., C. Hsu and C. Hoepting. 2013. Consequences of co-applying insecticides and fungicides for managing Thrips tabaci (Thysanoptera: Thripidae) on onion. Pest Management Science. 69: 841-849.

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Sharma-Poudyal, D., Paulitz, T., Porter, L., Eggers, J., Hamm, P., and du Toit, L.J. 2013. Effect of timing of glyphosate application to a winter cover crop on stunting of spring-sown onions caused by Rhizoctonia spp. in the Columbia Basin of Washington, 2012. Plant Disease Management Reports 7:V046.

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Wu, M., Goto, H., Waters, T.D., Walsh, D., & Lavine, L.S. 2013. Identification of an alternative Knockdown Resistance kdr-like mutation, M918L, and a novel mutation, V1010A, in the Thrips tabaci voltage-gated sodium channel gene. Pest Management Science.

Zaid, A. M. and Beer, S. V. 2014. Detection of Burkholderia cepacia in onion planting materials and onion seeds. Chapter 22 in M. Fatmi and N. W. Schaad, eds. APS Manual on Detection of Plant Pathogenic Bacteria in Seed and Planting Material. 2nd Ed. APS Press. St. Paul, MN. (In Press).

Other Activities

1. Research Reports: Abstracts and Papers at International Professional Meetings

du Toit, L.J. Neck rot identification and management based on Achilles' heel. Invited presentation, The UK Onion and Carrot Conference & Exhibition, 20-21 Nov. 2013, Peterborough, UK. (~350 people).

du Toit, L.J. Onion neck rot: Effective management based on Achille's heel. Invited presentation at the 62nd Annual Muck Vegetable Growers' Conference, 3-4 Apr. 2013, Bradford, Ontario, Canada.

Shock, C.C., E.B.G. Feibert, and J.M. Pinto. 2013. Review of two decades of progress in the development of successful drip irrigation for onions. International Irrigation Show, November 5-7, Austin, TX.

2. Research Reports: Abstracts and Papers at National Professional Meetings

Arif, M., Armstrong, C.M., Knerr, A.J., Lupien, S., Dugan, F.M., Du Toit, L.J., & Schroeder, B.K. (2013). Modification of oligo design for enhanced sensitivity of a DNA macroarray for detection of fungal onion bulb rot pathogens. Phytopathology 103:S2.8 (Abstr.). National meeting of the American Phytopathological Society, 10-14 Aug. 2013, Austin, TX.

Buckland, K., J. Reeve, D. Alston, C. Nischwitz, and D. Drost. 2013. Effects of Nitrogen Fertility and Crop Rotation on Onion Growth and Yield, Thrips Densities, and Iris Yellow Spot Virus, and Soil Properties. Agriculture, Ecosystems, and the Environment 177:63-74.

Cramer, C.S. 2013. Breeding for resistance to Iris yellow spot. W2008: Biology and Management of Iris yellow spot virus (IYSV) Other Diseases, and Thrips in Onions. Annual Meeting. Denver, CO. December 12, 2013.

Cramer, C.S. and N. Kamal. 2013. Measuring selection progress in onion germplasm after one selection cycle for reduced Iris yellow spot symptom expression. HortScience 48:S363. (Abstr.)

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Drost, D., D. Alston, and C. Nischwitz. 2013. IYSV and Thrips Management-Utah. Annual Meeting, W2008 Working Group. Denver CO. Dec 12, 2013.

Drost, D., D. Alston, and C. Nischwitz. 2013. Utah State Report. Annual Meeting, W2008 Working Group. Denver CO. Dec 12, 2013.

Dugan, F. M., Lupien, S. L., Vahling-Armstrong, C. M., Chastagner, G. A., and Schroeder, B. K. 2013. Host range of Penicillium spp. (blue mold) rotting bulb crops. Phytopathology

103:S2.37 (Abstr.). National meeting of the American Phytopathological Society, 10-14 Aug. 2013, Austin, TX.

Gourd, T., Hammon, R., Hammond, E., Moore, S., Schwartz, H., Sakata, R., and Petrocco, D. 2013. Economic and Biological Impact of Companion-Crop-Planted Onions to Non-Companion-Crop-Planted Onions. Galaxy Extension Conference, September 18, 2013. Pittsburgh, PA.

Hardin, J., Cranshaw, W., and Szostek, S. 2013. Thrips associated with the environs of onion fields in Colorado. American Entomological Society Meeting Poster, Nov. 12, 2013.

Hoepting, C.A., Nault, B. A., and S.V. Beer. 2013. Update on IYSV, Onion thrips and other diseases in New York. Annual Meeting for Multi-State Project W2008: Biology and Management of Iris yellow spot virus (IYSV), Thrips and Other Diseases in Onions. Denver, CO.

Nault, B. A., and C. A. Hoepting. 2013. Onion thrips management in onion in New York. Annual Meeting for Multi-State Project W2008: Biology and Management of Iris yellow spot virus (IYSV), Thrips and Other Diseases in Onions. Denver, CO.

Nault, B. A. and A. M. Shelton. 2013. It's not all fruit in the Big Apple: Vegetable pest management of onion thrips in onion and cabbage. In PI-E Section Symposium: Current Status of Vegetable Insect Pests in the USA. Entomological Society of America Annual Meeting, November 13, 2013, Austin, TX.

Pfeufer, E.E. and B.K. Gugino. 2013. Environmental factors and production practices associated with bacterial diseases of onion. 2013 Mid-Atlantic Fruit and Vegetable Convention Proceedings, PA Vegetable Growers Association, Richfield, PA. Pp. 171-174.

Reitz, S.R. 2013. Lessons learned from a distant land: Onion thrips and their management in the Pacific Northwest. Symposium on Thrips – Small Players with Big Damages, Annual Meeting of Florida Entomological Society, Naples, FL, 17 July.

Sharma-Poudyal, D., Paulitz, T., Porter, L., Eggers, J., Hamm, P.B., and du Toit, L.J. 2013. Rhizoctonia spp. dynamics and optimal timing of glyphosate application to cereal cover crops to manage onion stunting in Washington and Oregon. Oral presentation, national meeting of the American Phytopathological Society, 10-14 Aug. 2013, Austin, TX.

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Shock, C.C., E.B.G. Feibert, L.D. Saunders. 2013. Onion variety response to plant population and irrigation system. Annual Conference of the American Society of Horticultural Science, Palm Desert, CA, 25 July.

Shock, C.C., J.M. Pinto, H. Kreeft, R. Ross, T. Laubacher and B. Shock. 2013. E. coli and Onions. Treasure Valley Irrigation Conference, Four Rivers Cultural Center, Ontario, OR, 17 December.

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Smith, E. A., E. J. Shields, M. Fuchs and B. A. Nault. 2013. Diurnal dispersal of onion thrips, Thrips tabaci (Lindeman), in an onion ecosystem. Entomological Society of America Annual Meeting. Austin, TX. November 11, 2013.

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Waters, T.D. 2013. Thrips Management in Onion. Pacific Northwest Insect Management Conference, Portland, OR.

Waters, T.D., Pappu, H., Dutoit, L.J., Schroeder, B.K., & Wohleb, C.H. 2013. Update on IYSV and Thrips in Washington State. W2008, Denver, CO.

Waters, T.D., & Walsh, D. 2013. Thrips Management in Onion in Washington State. W2008, Denver, CO.

3. Reports at Grower meetings and field days

Alston, D. 2013. Activity of New Insecticide Modes-of-Action on Onion Thrips Life Stages. Utah Onion Association winter meeting, Brigham City, Utah. February 12, 2013.

Alston, D. 2013. Landscape effects on onion thrips, IYSV and onions. Utah Onion Association winter Summer Field Tour. Brigham City, Utah. August 13, 2013.

Alston, D., Nischwitz, C., and Drost, D. 2013. USU ipmPIPE Thrips/IYSV monitoring protocols and ipmPIPE and onion website information. Utah Onion Association Summer Field Tour. Brigham City, Utah. August 13, 2013.

Asselin, J.-A., Bonasera, J., Hoepting, C., Zaid, A. and Beer. S. 2013. Update on bacterial disease management. Orange County Onion School. March 1, 2013. Middletown, NY.

Baskett, J., Arif, M., Mavrodi D., Mavrodi O., and Schroeder B. K. Epifluorescence microscopy of temporal interactions of Enterobacter cloacae in onions. NSF REU Undergraduate Research Symposium, Washington State University, Pullman, WA, 2 August 2013.

Beer, S. V., 2013. Bacterial disease incidence and control in onions. 2013 New York State Onion Industry Council. Winter Meeting. Cornell Cooperative Extension. Ithaca, NY. February 21, 2013.

Bunn, B. and D. Alston. 2013. Influences of the Agricultural Landscape on Onion Thrips and IYSV. Utah Onion Association winter meeting, Brigham City, Utah. February 12, 2013.

Cramer, C.S. Screening onion entries for tolerance/resistance to thrips and Iris yellow spot virus. NM Onion Field Day. Las Cruces, NM. July 16, 2013.

Cramer, C.S. Breeding for resistance to Iris yellow spot. Pacific Northwest Vegetable Association Conference. Pasco, WA. November 13, 2013.

Cramer, C.S. Breeding for resistance to Iris yellow spot in onion. Hazera Genetics and Nickerson-Zwaan Onion Research Teams Annual Meeting. Visalia, CA. July 30, 2013.

Drost, D. 2013. Crop Rotations and Onion Productivity: Does Planting Date Really Matter. Utah Onion Association winter meeting, Brigham City, Utah. February 12, 2013.

Drost, D. 2013. 2013 Onion Variety Trial. Utah Onion Association Summer Field Tour. Brigham City, Utah. August 13, 2013.

du Toit, L.J. Disease management in onion seed crops: What? When? How? Columbia Basin Vegetable Seed Association Annual Meeting, 15 Jan. 2013, Moses Lake, WA. (~70 people)

du Toit, L.J. Emerging onion diseases in the Columbia Basin. Columbia Basin Crop Consultants' Association Short Course, 16-17 Jan. 2013, Moses Lake, WA (~120 people).

du Toit, L.J. Mycorrhizae in onion bulb crops. Organic Session. Pacific Northwest Vegetable Association 26th Annual Conference & Trade Show, 13-14 Nov. 2013, Kennewick, WA. (~75 people)

du Toit, L.J. Why was pink root so prevalent in 2013? Onion Session. Pacific Northwest Vegetable Association 26th Annual Conference & Trade Show, 13-14 Nov. 2013, Kennewick, WA. (~125 people)

Gugino, B.K. Vegetable disease update for 2013. PVGA Vegetable Grower Field Day, Southeast Agricultural Research and Extension Center, Manheim, PA. August 6, 2013.

Hoepting, C.A. 2013. Growing GIANT onions! And managing bacterial soft rot. Mohawk Valley Produce Auction Growers Meeting. Canajoharie, NY. December 5, 2013 (20 participants).

Hoepting, C.A. 2013. Best management practices for onion pests. North Country Allium School. Plattsburg, NY. October 22, 2013 (34 participants).

Hoepting, C.A. 2013. Best management practices for onion pests. North Country Allium School. Canton, NY. October 21, 2013 (25 participants).

Hoepting, C.A. Role of adjuvants in development of bacterial disease. Annual Elba Muck Onion Twilight Meeting. Elba, NY. August 8, 2013 (36 participants).

Hoepting, C.A. 2013. An IPM approach to managing bacterial diseases of onions. Bradford Muck Vegetable Conference. Bradford, Ontario, Canada. April 4, 2013 (70 participants).

Hoepting, C.A. 2013. Small-scale onion pest and disease update. Chautauqua Produce Auction Meeting. Clymer, NY. March 15, 2013 (35 participants).

Hoepting, C.A. 2013. Role of adjuvants in bacterial diseases of onions. NYS Onion Industry Annual Winter Meeting. Ithaca, NY. February 21, 2013 (12 participants).

Hoepting, C.A. 2013. An IPM approach to managing bacterial diseases of onion. 2013 University of Wisconsin Extension and Wisconsin Potato and Vegetable Growers' Association Grower Conference. Stevens Point, WI. February 6, 2013 (10 participants).

Hoepting, C.A. and B.A. Nault. Onion insect management update. Annual Elba Muck Onion Twilight Meeting. Elba, NY. August 8, 2013 (36 participants).

Hoepting, C.A and B.A. Nault. 2013. Winning the Battle: Controlling onion thrips in New York. Bradford Muck Vegetable Conference. Bradford, Ontario, Canada. April 4, 2013 (70 participants).

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Nault, B. A. 2013. Integrated pest management of onion thrips. In Onion session. Mid-Atlantic Fruit and Vegetable Convention, Hershey, PA. January 30, 2013.

Nault, B. A. 2013. Insect pests and management update. 2013 New York State Onion Industry Council Winter Meeting. Cornell Cooperative Extension. Ithaca, NY. February 21, 2013.

Nault, B. A. 2013. Insect management for onions. Orange County Onion School. March 1, 2013. Middletown, NY.

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Reitz, S.R. 2013. Onion thrips biology and management. Pacific Northwest Vegetable Association, Kennewick, WA, 13 November.

Schwartz, H. F. 2013 Onion virus management and updates. Annual Education Meeting of the Colorado Onion Association on January 31, 2013 at Eaton, CO.

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Shock, C.C. 2013. Food and Drug Administration Tour of Onion Production, Ontario, OR, 12 August.

Uchanski, M.E. Onion impPIPE project update; year 3. NM Onion Field Day. Las Cruces, NM. July 16, 2013.

Udquim, K.-I. T., Arif, M., du Toit, L.J., and Schroeder, B.K. 2013. Detection and discrimination of Botrytis species, causal agents of onion bulb rot, using quantitative polymerase chain reaction (qPCR) melting curve analysis. The Summer 2013 Undergraduate Research Poster Symposium at Washington State University, The Office of Undergraduate Research, 2 Aug. 2013, Pullman, WA.

Waters, T.D. 2013. Onion Insect Control. Walla Walla Farmers Co-Op Grower Meeting, Walla Walla, WA.

Waters, T.D. 2013. Insect Control in Vegetables. Pesticide Recertification Day, Ontario, OR.

Waters, T.D. 2013. Thrips Management in Onion. Pacific Northwest Vegetable Association, Kennewick, WA.

Waters, T.D. 2013. Insect Control in Onion. Farm Fair, Hermiston, OR.

Washington State University (WSU) Onion Cultivar Storage Demonstration Trial, L&L Farms, Othello, WA, 8 Feb. 2013. Evaluation of 55 onion cultivars (3 replicate plots of 55 bulbs evaluated/cultivar) for storage rots and storage quality. Organized by Tim Waters & Carrie Wohleb, WSU Extension Educators.

Presentations were given to ~75 growers, consultants, breeders, regulators, extension educators, graduate students, postdoctorates, researchers, etc. at the **2013 Washington State University Onion Field Day**, 29 August 2013, Hartley Farms, near Benton City, WA. The presentations covered materials included in the field day handouts, as listed above in the publications section.

Internet Resources

Hoepting, C.A. and S.V. Beer. 2013. Exploring the relationship between nitrogen, plant spacing and bacterial diseases of onion in New York: Reduced nitrogen and closer spacing could result in less rot. Cornell Vegetable Program website. http://rvpadmin.cce.cornell.edu/pdf/submission/pdf106_pdf.pdf

Hoepting, C.A. and S.V. Beer. 2013. Role of adjuvants in bacterial diseases of onions. Cornell Vegetable Program website. http://rvpadmin.cce.cornell.edu/pdf/submission/pdf115_pdf.pdf

Schwartz, H. F. 2013. Web site dedicated to information and resources on onion pest management and/or thrips and IYSV. http://www.alliumnet.com/index.htm

Onion Disease Management strategies, reports and publications, including those on IYSV and thrips and other diseases. http://www.colostate.edu/Orgs/VegNet/vegnet/onions.html

Onion ipmPIPE and Disease Diagnostics, including those on IYSV and thrips, in addition to other resources such as weather, forecasts, markets: http://apps.planalytics.com/aginsights/pipehome.jsp http://onion.coop/

Pacific Northwest Vegetable Extension Group (PNW VEG) website (http://mtvernon.wsu.edu/path_team/vegpath_team.htm)

with sections on onion diseases, pests, and other problems, as well as IPM resources: e.g., http://mtvernon.wsu.edu/path_team/onion.htm and
http://mtvernon.wsu.edu/path_team/ipmResources.htm#onion

Schwartz, H. F., and Gent, D. H. 2013. High Plains Integrated Pest Management Resource. On-line IPM bulletin with updated onion disease and pest reviews, and pesticide recommendations. http://wiki.bugwood.org/HPIPM%3AOnion

Preliminary studies on Escherichia coli and onion can be found in the Oregon State University Agricultural Experiment Station website.
http://www.cropinfo.net/crops/PrelininaryStudiesOnEcoliAndOnion_ExtCrS148_31Oct2013.pdf

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Ross, R.D., C.C. Shock, T.A. Laubacher, J.M. Pinto, A.C. Mahony, H. Kreeft, and B.M. Shock, 2013. Simulated filtration pond to remove Escherichia coli from irrigation water. In Shock, C.C. Ed. Preliminary studies on Escherichia coli and onion. Oregon State University Malheur Experiment Station, Department of Crop and Soil Science Special Report, Ext/CrS 148: 36-43.

Shock, C.C., E.B.G. Feibert, and L.D. Saunders. 2013. 2012 Onion variety trials. p 12-25 In Shock C.C. (Ed.) Oregon State University Agricultural Experiment Station, Malheur Experiment Station Annual Report 2012, Department of Crop and Soil Science Ext/CrS 144.
http://www.cropinfo.net/AnnualReports/2012/20121OnionVar.php

Shock, C.C., E.B.G. Feibert, and L.D. Saunders. 2013. Onion production from transplants and sets. p 26-34 In Shock C.C. (Ed.) Oregon State University Agricultural Experiment Station, Malheur Experiment Station Annual Report 2012, Department of Crop and Soil Science Ext/CrS 144. http://www.cropinfo.net/AnnualReports/2012/20122OnionTrans.php

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Other Related Activities

None reported.