**Minutes from the:**

**SAES-422 Multistate Research Project W-3008:**

**Integrated Onion Pest and Disease Management**

**ANNUAL MEETING**

**10:00 am to 12:00 pm**

Madison Concourse Hotel

1 W Dayton St

**Madison, WI**

**Jul 24, 2019**

**Meeting held preceding the NOA/NARC/IARS Allium conference, Jul 24- Jul 27, 2019**

**W3008 Committee Officers – 2019:**

**Chair:** Beth Gugino, The Pennsylvania State University

**Vice-Chair:** Bhabash Dutta, University of Georgia

**Secretary:** Peter Rogers, BASF Vegetable Seeds

**Past Chair:** Christy Hoepting, Cornell University

**Participants:**

|  |  |  |
| --- | --- | --- |
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The Chair Beth Gugino called the meeting to order at 10 AM.

Welcome and Introductions, W3008 status, 2020 annual report, comments from W-3008 Advisor Steve Loring

**W-3008 Committee for 2019:**

**Beth Gugino**, Chair - [bkgugino@psu.edu](mailto:bkgugino@psu.edu)

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**Christy Hoepting,** Past-Chair - [cah59@cornell.edu](mailto:cah59@cornell.edu)

**Comments from Steve Loring via email communication to Beth Gugino:** Not much to report from the national view. Most of you know that NIFA is moving to Kansas City despite objections from the land-grant system. Watch for RFPs in big areas and be prepared to collaborate.

Project level – State reports will be due to Bhabesh so that he can compile the annual report due in NMISS 60 days from this meeting in mid-September. Reminder about the importance of impact statements no just reports of activities.

**State Report Summaries:**

10:10 am Colorado – Mike Bartolo

* Onion acreage reduced from 12,000 to 4000 A over recent years; labor contributing factor
* Effort is being made to maintain the onion line Colorado 6
* Thaddeus Gourd – conducted the 2019 northern Colorado onion variety trial with Sakata Farms
* Created a planter box insert to convert a commercial Milton planter into a small plot planter
* Tyler Mason – focusing on organic weed management. Testing capric acid for weed control acting as contact herbicide, available for organic farmers
* Hiring a new insect vector virologist – Punya Nachappa
* The Colorado Fruit and Vegetable Growers Association is very active and held their annual meeting in Denver

10:20 am Georgia - Bhabesh Dutta

* Vidalia onion in GA has a $160 M farm gate value; grown on 11,000 A in 21 counties
* Center rot and sour skin are major problems
* Botrytis leaf blight was widespread but not severe in 2019. Conducted a fungicide trial – Omega 500 was superior, Rovral did not work well; program with Luna tranquility or Omega 500 or Miravis prime in rotation with Inspire Super and Scala were effective; growers rely on phosphites (ProPhyt vs Kphite) – ProPhyt was significantly better
* In 2018 downy mildew was only at research station but in 2019 it was more widespread but only moderate– conducted a fungicide trial on commercial farm – Orondis Ultra + Bravo alt with Omega 500 + Bravo were effective.

10:30 am Idaho – Mike Thorton

* Treasure Valley – 22,000 A and over 75% of growers have adopted drip irrigation compared to traditionally used surface irrigation
* 2019 crop – Wettest April in record. Herbicide issues and bulb mites caused low stands;
* Three research groups working on onion
  + James Woodhall – is spore trapping with a Burkhart sampler for Botrytis; conducting soilborne pathogen assays for soil pathogen through a Specialty Crop Block Grant looking at *Fusarium* *proliferatum* and *Setophoma* *terrestris*
  + Brenda Schroeder – Working on *Fusarium proliferatum* and evaluating onion variety lines for resistance
  + Mike Thorton – Evaluating use of Fontelis for Pink root through the drip; using remote sensing to map where pink root is most severe during the field in season to make management decisions later in the year; working on long-term storage issues caused by *Botrytis* *alli* or *Fusarium* *proliferatum* - prior to 2015 the issue was primarily Botrytis, in 2015-16 Fusarium became more problematic; most important issue seems to vary by year

10:40 am New Mexico - Chris Cramer

* Good year for onion production; June 10th, unusual 2 to 3 in. of rainfall with 60°F temperature flanked by hot days with temperature over 100 °F.
* Working on breeding resistance to Fusarium bulb rot; application of mature bulb screening technique to 7 populations for FBR R (SD Granex types).
* Also breeding resistance to Thrips and IYSV – germplasm evaluated (waxy vs glossy leaves); 4 Semi Glossy, 1 Glossy, and Rumba waxy. Measurements on same 10 plants per plot during the season were made
* Trials arranged in a split-plot design evaluating the effect of irrigation treatments (well-watered vs limited water) with water status as whole plot and germplasm as split plot

10:50 am New York - Christy Hoepting and Brian Nault

* 7600 A in muck onion production
* 2019 was one of coldest and wettest springs; delayed planting and many acres planted later than desired; some acreage didn’t get planted (maybe 10%). Uneven stands due to planting wet but total stand was good
* EverGol Prime - new smut seed treatment
* Growers are getting good weed control, but injury was higher than usual
* Last day of spring got 3 to 7 in. of rain in Oswego so there were 2500 A underwater, but plants recovered
* End of June – finally warmed up – low disease and thrips pressure
* Soilborne diseases –issues with PR and FBR, more than ever in 2018.
  + Lead to 2019 trial to evaluate 17 in-furrow fungicides and biologicals treatments for control of pink root and Fusarium basal rot
* Stemphylium and BLB/fungicide programs and timings were examined. Conventional and organic products were evaluated. Determined if Bravo interferes with performance of translaminar fungicide as it does with translaminar/systemic insecticides
* Bacterial bulb rot trials, 2nd year; 9 varieties tested
  + No crop response to N last year up to 135 lbs/A. This year 10-30-60 lb/A was evaluated
* Onion maggot projects –Evaluating relationships between onion maggot adult activity and onion maggot damage
  + Identify how Spinosad protected onion seedlings from onion maggot if not systemic?
  + Novel insecticide seed treatments
  + Onion maggot transplanted onions – dipped with Entrust – interest in using plant tape and plug transplants
  + Also entomopathogenic nematodes for OM
* Onion Thrips projects\_ Evaluating IPM tactics for Thrips & IYSV control, along with Stemphylium on organic onions
* Allium leaf miner project with Penn State; Allium leaf miner (ALM) control, testing conventional insecticides and OMRI-listed products. Insecticide program for ALM control in conventional and organic onions
  + Evaluating color patterns of sticky cards for monitoring of adults. Yellow does not work
  + Degree-days study to determine emergence predictability

11:00 am Pennsylvania – Beth Gugino

* Similar challenges with weather and crop emergence as NY;
* Spanish cultivar Candy main cultivar grown. Transplants from AZ mainly. Planting March-mid April. Wet season as in NY.
* Simply sweet onions branded in Pennsylvania. Ninety onion growers with 125 A. Growers are concerned that variety Candy will be not be available for sale. Testing variety Sunbelt Sweet that showed high susceptibility to bacterial pathogens. *Panteoa* spp. (*P*. *ananatis* or *P*. *agglomerans*?) concerned as causal agents.
* 2019 IR-4 trial (same as Lindsay in WA) and timing inoculation method trial.

11:10 am Texas – Subas Malla

* Conducted thrips studies in 2017-18 and 2018-19; studying population and insecticide treatments; no IYSV detected in 2018-19.
* 2018-19 downy mildew and Stemphylium nursery were used for germplasm screening in organic system
* Hailstorm injury in past year followed by secondary bacterial infection
* Evalauting NDVI correlation with disease in field with plant height, leaf number, and neck diameter
* Onion seed production failed in 2017 but was able to produce a crop in 2018
* Winrhizo software to characterize root in field with pink root vs. not

11:20 am Utah - Dan Drost

* Acreage down 10-15% to 1800 A
* 90% acreage went in after 20th April – every week plant later than Apr 15th, lose 10% yield (stopped planting May 1st). Spring rain excessive so ground prep was problematic
* Establishment was good considering the poor seed bed condition; plant to plant variability was horrendous some at 3 leaf and some at 10 leaf stage – not sure what was contributing to non-uniformity
* Growers are heavily invested in drip irrigation went from 5% on drip to 75% on drip – but growers still have a furrow irrigation mentality when using drip – once per week for 24 h (some only have access to water once per week) – so investing in ponds to hold water that can be used to meter out drip – state is invested in making this work – growers switching to drip also need to consider changing other practices like seed density – the spacing is wide so getting too many colossal and super colossal using furrow irrigation seeding rates

11:30 am Washington - Tim Waters and Lindsey du Toit

* Columbia Washington basin - cold late spring with snow – delayed planting but things are looking good despite some hail storms
* Downy mildew in bulb crops due to weather which is atypical usually see it in the seed crop
* The onion alert system has been successful with 646 subscribers (started in 2007) – modeled off the potato alert system
* Contributing to SCRI project to screen germplasm for resistance to Fusarium and Pink root
* Fusarium basal rot trial using Fontelis to evaluate disease control
* Cultivar trial – 40 cultivars – Aug 29th field day
* Thrips project with Tim Waters
* SCRI project on bacterial disease, 4 million was recommended for funding. Not official yet. Twenty four people, 12 states and 1 other country. Many growers will be involved on this project.

**Organizational Items**

11:30 am Election of new officers – revisit discussion from last year

* Two nominations last year resulted in Peter Rogers serving as Secretary in 2019 and David Burrell from National Onion Labs will serve in 2020. We welcome David Burrell to the W3008 Officers Committee for 2020.

11:35 am Discussion of 2020 annual meeting location & date

* There was extensive discussion about where and when to host the meeting. The first option would be to hold it in conjunction with the 2021 Southeast Fruit and Vegetable Convention in Savannah, GA. Beth Gugino will check with Steve Loring to see if this is allowable since it does not fall in the 2020 calendar year. The second option is to have an airport meeting in Atlanta in fall 2020. Bhabesh Dutta and David Burrell will serve as local arrangements in either case.

12:00 pmAdjourn

**3. Accomplishments (29,846 characters with spaces; allowed 30,000 characters with spaces)**

**Objective 1. Evaluate onion germplasm for resistance to pathogens and insects**.

**New Mexico** (**Cramer**): In October 2018, onion bulbs were placed on the first and last bed of the study and at the front and back borders of the field study. In addition, seed of ‘NuMex Freedom’ was sown at the same time on every seventh bed to ensure that thrips are spread throughout the field the following year. On 7 January 2019, seed of four NMSU germplasm lines and ‘Rumba’, an IYS-susceptible cultivar was sown in flats at the Fabian Garcia Science Center in Las Cruces, NM. Ten plants were randomly-selected from each plot and identified with a plastic label. Starting on 8 May 2019 and four additional times two weeks apart, the number of adult and juvenile thrips were counted from each of the ten plants from each plot. On 5 June 2019, the severity of Iris yellow spot symptoms was rated for each of the ten plants. These ratings were repeated for two additional times two weeks apart. At 8, 10, and 12 weeks after transplanting, plants of ’Rumba’ possessed more juvenile and total thrips than plants of the four NMSU germplasm lines. At 12, 14, and 16 weeks, plants of ‘Rumba’ exhibited more severe Iris yellow spot disease symptoms than plants of all other four entries.

**New York** (**Nault, Hoepting, Pethybridge, Hay**): Over the past two years, a study was conducted to evaluate multiple tactics to manage onion thrips in organically produced onion. Two mulch types (reflective and white), two semi-glossy “thrips-resistant” cultivars (‘Rossa di Milano’ and B5336 x B5351) and one waxy “thrips-susceptible” cultivar (‘Bradley’), and two insecticide treatments (Entrust and untreated control) were evaluated. Total numbers of thrips larvae were higher on onions grown on white mulch than on reflective mulch in 2019, but the opposite was true in 2018. In both years, more thrips were encountered in the Bradley cultivar than in the thrips-resistant cultivars, and more in untreated control plots than in Entrust-treated plots. In 2018, marketable bulb yields were highest on onions grown on reflective mulch compared with white mulch, higher in Bradley and B5336 x B5351 cultivars than Rossa di Milano, and higher in Entrust than the untreated control. Overall, the most effective tactics for reducing onion thrips infestations while maintaining acceptable marketable yields were to use either Bradley or B5336 x B5351 cultivars, reflective mulch and Entrust.

Over the past two years, a study was conducted to evaluate the effect of onion variety and nitrogen on bacterial bulb rot. In 2018 and 2019, two trials were conducted in commercial onion fields in ‘muck’ soil in Elba and Oswego, NY. Seven onion varieties were compared across 37, 100 and 150 lb/A of nitrogen. Artificial toothpick prick and backpack sprayer inoculation techniques with *Pantoea ananatis* and *P. agglomerans* were also included. In 2018, Nitrogen had no effect on yield or bacterial bulb rot, so data per variety was pooled across nitrogen treatments. Bacterial bulb rot pressure was moderate with natural infection levels greater than 10% and 25% in Oswego and Elba, respectively. In both trials, Trailblazer had the least natural bulb rot, which was not significantly different from Saddleback and Braddock, while Red Wing had the most natural bulb rot, which was not significantly different from Montclair, Pocono and Catskill. Varieties that had the most natural bulb rot also had the largest neck diameter, while the varieties with the smallest neck diameter had the least bulb rot. Although there were no significant differences among varieties for bulb rot when they were artificially spray-inoculated, incidence of bulb rot was 16 to 40% higher than natural infection for all varieties except Red Wing. Artificial prick-inoculation increased bulb rot over natural infection in all varieties by 24 to 300% and differences among varieties for incidence of bulb rot was the not the same as natural infection. For example, Red Wing did not have the highest level of bulb rot with artificial prick-inoculation. Instead, Red Wing was not significantly different then Trailblazer, which again had the least bulb rot. In both trials, Montclair and Braddock were two of the top-yielding varieties, while the variety most tolerant to bulb decay, Trailblazer and the variety most susceptible to bulb rot, Red Wing had the lowest yields. Overall, these onion varieties were consistent in their relative susceptibility to bacterial bulb rot, with incidence increasing with days to maturity and neck diameter. Artificial inoculation techniques demonstrated promise for increasing disease incidence.

**Oregon (Reitz, Dung and Shock):** Thrips and IYSV are the most important pests of onions grown in the Treasure Valley of eastern Oregon and southwest Idaho. As part of ongoing onion variety trials conducted at the Malheur Experiment Station, varieties are rated during the season for thrips damage and severity of iris yellow spot. In 2018 trials, IYS was present in all cultivars, but at relatively low levels. Thrips feeding damage varied among cultivars. Red cultivars had greater levels of thrips feeding damage than with yellow cultivars. Within each color, there were significant differences among cultivars in terms of thrips feeding damage.

**Texas** (**Malla**): During 2018-19 season, foliar disease complex of downy mildew, botrytis leaf blight and Stemphylium leaf blight was observed in onion. The foliar disease severity was higher in the seed production and organic nursery. The higher foliar severity also resulted in higher percentage of bulb rot. A total of 23 Texas A&M (TAM) lines were evaluated for yield in the organic system. The germplasm showed variation for foliar disease resistance. The foliar disease severity was rated on a scale of 0 to 9, where 0 = immune and 9 = highly susceptible. TAM Experimental (Expt) #50084 and TAM Expt #31034 had the least disease with a severity rating of 2, whereas TAM Expt #43053 and TAM Expt #43044 had the highest disease with a severity rating of 8. Elite yield trial, consisting of 23 TAM elite germplasm and 18 commercial checks, was evaluated for pink root resistance in the conventional system. The germplasm were evaluated in the pink root screening nursery, where the germplasm had been evaluated for pink root resistance for the third consecutive year. Pink root was rated during harvest on a percentage of root infection where 0% = immune and 100% = highly susceptible. Yellow H6 had the least pink root severity (10%) followed by TAM Expt #31034 (17.5%). TAM Expt #34036 had the highest disease severity of 85%.

Advanced germplasm from TAM were also evaluated for pink root resistance. A total of 36 germplasm (23 advanced lines from TAM and 13 from commercial checks) were screened for pink root resistance in the nursery. TAM Expt #41066 had the least disease severity (7.5%) followed by TAM Expt #50020-2 (12.5%), whereas TAM Expt #40017 had the highest pink root severity (70%). A total of 220 TAM preliminary lines were also evaluated for pink root resistance in the preliminary yield trial in the pink root screening nursery. Ten germplasm (TAM Expt #: 33015, 40026, 40027, 40060, 40061, 40066, 40067, 90519, 92007 and 92021) had the pink root severity of 5% indicating that the germplasms have resistance against the disease.

**Washington** (**du Toit, Waters, Pappu**): The Washington State University onion cultivar trial was planted in May 2019 near Connell, WA, with three replicate plots of each of 47 cultivars submitted by various onion seed companies. The plots were evaluated regularly for diseases and pests. In August, the plots were rated for percentage tops down as well as the severity of powdery mildew, a disease not often seen in the Columbia Basin but which showed up more than normal during the 2019 season with some significant differences observed among the cultivars in this trial. Bulbs will be harvested from the plots in September to assess yield, and 50 bulbs/plot will be placed in storage to evaluate for storage quality and storage rots in February 2020. Several cultivars and breeding lines were evaluated for their response to Iris yellow spot virus infection under field conditions. Symptom severity, final disease incidence and relative virus levels are used to as criteria to identify cultivars with virus resistance or tolerance.

**Objective 2. Investigate the biology, ecology and management of onion thrips and other pests.**

**New York** (**Nault, Hoepting, Pethybridge, Hay**): A three-year experiment was conducted to identify an insecticide and rate that most effectively reduces a very high onion thrips infestation. Minecto Pro (abamectin plus cyantranilprole), Exirel (cyantraniliprole) and Radiant SC (spinetoram) were evaluated at their lowest and highest recommended rates. All treatments were applied twice one week apart beginning when the thrips larval density was 3-4 per leaf. Extremely high infestations occurred only in one of the three years of the study (2018). In that study, one week after the second application, only Radiant at 10 fl oz/A significantly reduced the thrips density to below 2.2 larvae per leaf (economic injury level). Densities of larvae in the Minecto Pro and Exirel treatments were all above 4 larvae per leaf and 2.7 per leaf in the low rate of Radiant. The high rate of Radiant SC should be considered the best option for providing the greatest reduction of a high thrips infestation. In a two-year study, the best combinations of OMRI-listed insecticides and adjuvants were evaluated for managing onion thrips in organically produced onions. Four insecticides (Azera, Entrust, Neemix and PFR 97) and three adjuvants (M-Pede, Nu-Film and Trilogy) were applied weekly. Entrust co-applied with either M-Pede or Trilogy consistently provided the best thrips control. Insecticide seed treatment performance was evaluated for managing very high onion maggot infestations in 2019. Onion maggots killed nearly 100 percent of the plants in the fungicide-only control. Similarly, the percentage of plants killed in the Lorsban Advanced drench treatment was also near 100 percent. The seed treatment Regard significantly reduced the percentage of maggot damage compared with levels in the control and the Lorsban treatment, but still suffered over one-third of the plants being killed by maggots. The least amount of onion maggot damage occurred in BASF 450, which only had 5 percent plants killed by maggots. BASF 450 will be considered for future research as it has tremendous promise as an excellent new insecticide for onion maggot control. Insecticides that would effectively protect Allium crops from damage caused by the new invasive Allium leafminer (ALM) were also evaluated in 2018. Conventional and OMRI-listed products were applied weekly on bulb onion, leek and scallion. Pressure was moderate to high in the experiments. The most consistent and best performing conventional treatments included Scorpion (dinotefuran), Exirel (cyantraniliprole) and Radiant (spinetoram), while the best performing OMRI-listed product was Entrust (spinosad).

**Oregon (Reitz, Dung and Shock):** Ongoing insecticide efficacy trials demonstrated effectiveness of new insecticide use programs to better manage thrips and IYSV in the Treasure Valley. As part of a USDA-SCRI grant (Pappu et al. Development and Delivery of Integrated Management Packages for the Most Serious Pest and Diseases Threatening the US Allium Industries), we are conducting field trials to assess how nitrogen fertilization combined with insecticide management programs based on sampling thresholds or scheduled applications affect thrips and iris yellow spot. Field trials conducted in 2018 and 2019 demonstrate a decline in the efficacy of methomyl against thrips populations in the Treasure Valley. A regional pest-monitoring program provided information to growers on seasonal pest trends, including changing patterns in thrips and IYS incidence in the Treasure Valley.

**Washington** (**du Toit, Waters, Pappu**): Previous study by the Walsh lab at the WSU IAREC in Prosser documented the universal incidence of resistance to pyrethroids among onion thrips populations in Washington State. Another class of insecticide commonly used for thrips control in onions is the carbamates, i.e., oxamyl (Vydate) and methomyl (Lannate LV). Methomyl and oxamyl are often applied multiple times to individual fields over the course of the growing season, and both have been used on onions for over 25 years. We evaluated the tolerance of onion thrips to field doses of oxamyl and methomyl. Commercial fields with a history of oxamyl and methomyl use contained thrips populations that were far less susceptible to those insecticides than thrips from fields where these insecticides had not been used. This demonstrated that resistance is present in thrips populations in the Columbia Basin of Washington State. We have confirmed again that when seedcorn maggot is present as a pest in a field, seed treatments can increase plant stand and, therefore, yield and quality of onion crops. Commercial producers are now aware of this technology and adoption is widespread. In conventional crops, we have shown that 4 active ingredients (dpinetoram, methomyl, abamectin, and cyantraniliprole) are highly effective for control and one (spirotetremat) is somewhat effective. Producers now need better information on the timing and appropriate sequences of application of these products. Organic producers still have limited options. One active ingredient (spinosad) has been shown to be effective, and the efficacy is enhanced with two different tank mix partners (azadiractin and a *Burkolderia* sp). Additionally, we determined that three organic products applied alone were ineffective for thrips control (Celite, Venerate, and AzaDirect).

**Objective 3. Investigate the biology, epidemiology and management of onion plant pathogens.**

**California** (**Putnam**): Field trials were initiated in Holtville, CA (October 2018) and Brawley, CA (November 2018) to evaluate the utility of weather-based models to schedule fungicide applications to manage downy mildew of onions for processing. A weather station was established within the Holtville trial to measure standard parameters at a height of 2 m, plus temperature, relative humidity, and leaf wetness within the plant canopy. A weather station was not installed at the Brawley location due to slow crop development. None of the models were triggered at any time during the course of the monitoring period. Two applications of the standard calendar-based treatment were made based on subjective assessments of weather conditions. Downy mildew was not observed in the both trials, consistent with overall very low downy mildew pressure in the California desert in the winter of 2018-2019.

**Georgia** (**Dutta, Kvitko**): We identified susceptible growth stages (first leaf senescence, bulb initiation and bulb swelling) of onion to *P. ananatis*-bulb infection. Multi-year field trials were conducted to evaluate if onion growth stage directed chemical protection can reduce center rot bulb incidence. Onion plants were protected with agrichemicals at all three growth stages. The field plots were aggressively protected with insecticides for thrips control. The results indicate that Kocide 3000 or Kocide 3000 with Actigard when applied at either bulb initiation or bulb swelling stage can significantly reduce disease incidence in bulbs compared with Actigard only and the untreated control. In 2019, field trial was designed to evaluate the growth-stage directed spray in conjunction with or without a thrips management program. For treatments where thrips management program was not utilized, non-bactericide treated check had significantly higher center rot incidence in bulb and also resulted in lower marketable yield compared to other treatments. Treatments with either Agrititan (nano-formulation of TiO2; 1% v/v) or Kocide 3000 (1.5 lb/A)+Agrititan (1% v/v) had significantly lower center rot bulb incidence and higher marketable yield compared to other treatments. For treatments where thrips management program was followed, non-bactericide treated check plots had significantly higher center rot incidence in bulb and lower marketable yield compared to other treatments. Treatment with Kocide 3000+Agrititan had significantly lower center rot bulb incidence and higher marketable yield compared to other treatments. Based on comparisons of the complete DNA sequences of onion virulent and non-virulent strains, two clusters of genes were identified that were strongly correlated with the ability of a Pantoea strain to cause disease on onion. We generated strains lacking these genes to determine what roles they play in center rot. The first cluster of disease-associated genes, HiVir, are required for Pantoea to cause damage to both onion leaves and bulbs and are consistent with genes that would allow the bacteria to produce a plant herbicidal toxin. The second cluster of disease-associated genes, alt, allow the bacteria to tolerate the noxious sulfur compounds released by damaged onions. We have found that both gene clusters combined are required for Pantoea to colonize onion bulbs. We have used these two disease-associated gene clusters as the basis for the development of simple diagnostic assays. The red onion scale clearing assay, which can identify strains that carry the HiVir toxin cluster, and a multiplex PCR assay that can identify both HiVir and alt cluster. These assays can readily distinguish disease-causing Pantoea from harmless environmental strains as well as identify strains that may pose an increased risk of post-harvest onion bulb disease.

**New York** (**Nault, Hoepting, Pethybridge, Hay**): Two projects on Stemphylium leaf blight (SLB) have been completed in 2019 (NY Farm Viability Institute, Specialty Crop Block Grant SCG 16-008 and NIFA CPPM NYG-625591). Stemphylium leaf blight has become a dominant foliar pathogen of onion in NY and phylogenetic analysis has confirmed the species involved as *S. vesicarium*. A large proportion of the *S. vesicarium* population collected from onion around NY exhibited insensitivity in the laboratory to active ingredients in the FRAC 11 group (azoxystrobin and pyraclostrobin) and FRAC 7 (boscalid) group. On the basis of this, and a recently observed decline in efficacy in the field (see below), the use of fungicides based solely on these active ingredients has been curtailed by the onion industry in NY. Laboratory tests indicated a moderate level of insensitivity in the *S. vesicarium* population to FRAC 9 (cyprodinil and pyrimethanil). This, coupled with observations of only moderate efficacy of fungicides based solely on these ingredients in the field suggests the development of fungicide resistance in this group. FRAC 9 fungicides remain in use against SLB, often in mixtures with other FRAC groups, but will continue to be monitored for evidence of field failures against SLB. There was little or no evidence of fungicide insensitivity to FRAC 7 (fluopyram and fluxapyroxad), FRAC 3 (difenoconazole), or FRAC 2 (iprodione) active ingredients in the laboratory, and products containing these ingredients currently remain the basis of fungicide management strategies for SLB in NY. Ongoing sensitivity testing in 2019 has indicated further shifts in fungicide sensitivity. Two field trials confirmed leaf debris from preceding onion crops was a significant source of inoculum of *S. vesicarium* into the following onion crop, and methods to encourage decomposition of debris over winter reduced disease incidence in the following crop early in the season. *S. vesicarium* was detected rarely in weeds within and surrounding fields in Elba, NY soon after planting, indicating that weeds could be a source of inoculum, but may not be a significant source. *S. vesicarium* was not detected in commercial organic seed lots of 13 varieties of onion harvested in 2016 (n = 1300 seeds), or 15 varieties harvested in 2017 (n = 1500 seeds). A field trial to screen OMRI listed products against SLB, identified Badge X2 and Kocide 3000-O as having moderate efficacy, with significantly lower disease severity than the non-treated control in a situation of moderate disease pressure. Oso, which is currently undergoing consideration for OMRI listing, also provided a significant, but moderate level of control.

**Oregon (Reitz, Dung and Shock):** White rot trials were conducted in Tulelake, CA and western Fresno County, CA on onion and garlic, respectively. Main plot treatments consisted of biostimulants that were shank-injected in the spring and/or fall prior to planting. Tebuconazole was applied in-furrow as a split-plot treatment at both sites at planting. At the Tulelake site, the greatest reductions in sclerotia populations were observed in plots treated with garlic oil in the spring and fall, DADS, and garlic oil (spring) + allyl isothiocyanate (fall). In-furrow applications of tebuconazole significantly increased onion stand and reduced late season onion leaf dieback and AUDPC values compared to the no-fungicide control. Garlic oil (spring) + allyl isothiocyanate (fall), garlic juice (spring), and garlic oil (spring and fall) exhibited the highest yields of disease-free onion bulbs. In-furrow applications of tebuconazole increased disease-free onion yield compared to the no-fungicide control. At the Fresno site, in-furrow applications of tebuconazole increased total garlic yield and decreased the number of garlic bulbs with severe disease symptoms. Sclerotia populations increased greatly from onion and garlic planting to harvest at both sites in plots not treated with an in-furrow application of tebuconazole, suggesting that tebuconazole may help prevent the buildup of sclerotia in fields after an Allium crop.

**Pennsylvania (Gugino):** During the 2019 production season, two onion center rot trials were conducted. One was in partnership with IR-4 to evaluate the performance of 14 commercial as well as experimental products for the management of center rot of onion caused by *P. agglomerans* and *P. ananatis* (considered a pest problem without a solution by IR-4). The treatments plus a non-treated control were evaluated in a randomized complete block design with four replicates. Applications were initiated prior to toothpick inoculation of the pathogens. Data on disease severity as well as harvest data were collected. A subset of marketable onions from each treatment has been placed in storage for evaluation in mid- to late October. The data collected to-date is in the process of being analyzed. A second replicated multi-factorial center rot (*P. agglomerans* and *P. ananatis*) research trial was established in partnership with the Pennsylvania Vegetable Growers Association to evaluate several bacterial inoculation methods (three methods) and inoculation timing (three plant growth stages). The goal being to identify a consistent inoculation method and time to inoculate the plants to achieve uniform disease distribution throughout plots in the field. Data on disease severity as well as harvest data were collected and are in the process of being analyzed.

**Texas** (**Malla**): Trials were conducted to correlate Normalized Difference Vegetative Index (NDVI) , foliar disease severity and onion marketable yield A correlation between foliar disease rating and marketable yield was high (r = -0.80) in the elite yield trial in the organic system. A correlation was also high (r = -0.76) between NDVI and marketable yield. In the elite yield trial in pink root screening nursery (conventional system), a lower correlation (r = -0.27) was observed between pink root severity and marketable yield, but a higher correlation (r = 0.72) was observed between NDVI and marketable yield. The correlation between NDVI and pink root severity was -0.53. High-throughput phenotyping (HTP) using NDVI resulted in moderate to higher correlation among NDVI, disease severity and marketable yield.

**Washington** (**du Toit, Waters, Pappu**): A field trial funded by the IR-4 Minor Crops program was planted in Pasco, WA in spring 2019 to evaluate the efficacy of 14 treatments (products) for control of bacterial leaf blight and bulb rots caused by *Burkholderia gladioli* pv. *alliicola* and *Pantoea agglomerans*, using a randomized complete block design with four replicate plots. Products applied to main plots (each 2 beds wide) included ManKocide, Kocide 3000-O, Champ WG, Oxidate 2.0, Kasumin 2L (at 2 rates), Nano-magnesium oxide, GWN 10120, SP8010 (alone with tank-mixed with Kocide 3000-O or SP2700), Lifegard WG, and Instill. Each product was applied three to seven times at weekly or 5-day intervals, depending on the label restrictions. Split plots (each a single bed x 15 feet) were either inoculated twice with the two bacterial pathogens or not inoculated (water), using a backpack sprayer to apply inoculum. The final application was completed the last week of August. Plots were rated weekly for the incidence and severity of foliar bacterial symptoms. Bulbs will be harvested in September, with 50 bulbs cut and rated for bacterial rots at harvest and another 50 bulbs placed in storage for evaluation of storage rots in February 2020.

**Objective 4. Facilitate discussions between W3008 participants and onion industry stakeholders that will advance onion pest and disease management.**

**Georgia (Dutta):** Two trainings for county extension agents and professionals in Georgia, 10 Georgia producer trainings, and 3 national or regional invited extension presentations were conducted to disseminate updated information on onion disease management. These meetings have covered onion disease management through transfer of information and technology in Georgia.

**Pennsylvania (Gugino)** Research results were disseminated through one-on-one interactions with growers as well as participation in the 2019 International Allium Convention in Madison, WI in July.

**Washington** (**du Toit, Waters, Pappu**): Newsletter articles were written and distributed to >600 subscribers, mostly in the Pacific Northwest USA, via the WSU Onion Alerts (<https://mailchi.mp/wsu/wsu-onion-alert-aug-14-1303793?e=72ba613792>). Time-sensitive topics covered in seven articles between May 30 and August 21 of 2019 included downy mildew, fungicides, thrips, nematodes, iris yellow spot, irrigation, and powdery mildew. A grant proposal titled ‘Stop the rot: Combating onion bacterial diseases with pathogenomic tools and enhanced management strategies’ was submitted to the USDA NIFA Specialty Crops Research Initiative (SCRI) in May 2019. The proposal was led by Lindsey du Toit from WSU, with 5 co-PIs, 18 other collaborators from 12 states in the USA and one other country, with guidance/input from 12 onion growers/stakeholders serving on the project Stakeholder Advisory Panel. The proposal was recommended for funding at $4.0 million with matching funding of $4.2 million. The 4-year project will start in fall 2019.

**New York** (**Nault, Hoepting, Pethybridge, Hay**): 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. Details of these interactions are included in the Presentations section.

**Oregon** (Reitz, Dung and Shock): We published an updated IPM Strategic Plan for Treasure Valley Onions that documents the current status of pest management for the industry and its critical needs (Murray, Reitz and Jepson. 2019. An Integrated Pest Management Strategic Plan for Treasure Valley Onions: Oregon and Idaho). The IPMSP will be available through the Western Region IPM Center <http://westernipm.org/>.

**4. Impacts**

**California (Putnam**): Two field trials were initiated in the California desert in fall 2018 to evaluate the utility of four weather-based models to schedule fungicide applications to manage downy mildew of onions for processing. Under low disease pressure, two applications were made for the standard calendar-based treatment, whereas 0 applications were made for weather-based treatments because these models were not triggered.

**Georgia** (Dutta, Kvitko): Our results suggest that onion-growth stage based targeted spray under strong thrips control settings can reduce frequency/number of copper spray (at least 4 to 6), which may account for $40-60/acre in chemical savings. If labor and equipment operation are included then the total savings may account for $70-90/acre. If the improved management strategy is utilized over the entire onion acreage in Georgia (11,000 acres), a total savings of $770,000 to $990,000 can potentially be achieved.

**New Mexico** (Cramer): Breeding for reduced Iris yellow spot disease symptom severity has been successful in developing onion germplasm that is more resistant to this disease than some commercial cultivars. In addition, germplasm has been developed that is less attractive to onion thrips than some commercial cultivars.

**Washington** (du Toit, Waters, Pappu): Collaborative efforts and networking of W-3008 members led to successful submission and funding of a $4.0 million + $4.2 million matching funding, 4-year USDA NIFA SCRI grant to help onion stakeholders address the negative impacts of bacterial diseases on onion production in the USA. The project was ranked highly by the review panel, particularly the well-established national network of collaboration among 24 onion researchers and extension specialists with growers and other onion stakeholders across the USA. This productive collaboration has resulted, in part, from the many years of synergistic interactions through the W-1008, W-2008, and now the W-3008.

**5. Publications (December 1, 2018 to September 30, 2019) 50,000 characters**

**Journal articles**:

Hay, F., Sharma, S., Hoepting, C.A., Strickland, D., Luong, K. and Pethybridge, S.J. 2019. Emergence of Stemphylium Leaf Blight of Onion in New York Associated with Fungicide Resistance. Plant Disease, (ja).

Knerr, A.J., Wheeler, D., Schlatter, D., Sharma-Poudyal, D., du Toit, L.J., and Paulitz, T.C. 2019. Arbuscular mycorrhizal fungal communities in organic and conventional onion crops in the Columbia Basin of the Pacific Northwest USA. Phytobiomes 2:194-207.

Leach, A.B., Fuchs, M. Harding, R.S. and Nault, B.A. 2019. Iris yellow spot virus prolongs the adult lifespan of its primary vector, onion thrips (Thrips tabaci). Journal of Insect Science 19(3):1-4. <https://doi.org/10.1093/jisesa/iez041>

Leach, A.B., Hay, F., Harding, R.S. Damann, K.C. and Nault, B.A. 2019. Relationship between onion thrips (Thrips tabaci) and *Stemphylium versicarium* in the development of Stemphylium leaf blight in onion. Annals of Applied Biology (in press).

Leach, A.B., Hoepting, C.A. and Nault, B.A. 2019. Grower adoption of insecticide resistance management practices increase with extension-based program. Pest Management Science 75:515-526.

Murray, M.K., Reitz, S. and Jepson, P. 2019. An Integrated Pest Management Strategic Plan for Treasure Valley Onions: Oregon and Idaho. Western Region Integrated Pest Management Center. (in press)

Moretti, E.A., Harding, R.S., Scott, J.G. and Nault, B.A. 2019. Monitoring onion thrips (*Thysanoptera: Thripidae*) susceptibility to spinetoram in New York onion fields. Journal of Economic Entomolology. 112(3):1493-1497.

Rahimi, S., Hseih, S., Renlin, Xu., Avis, Tyler, A., Smith, D., Dutta, B., Gitaitis, R. and Tambong, J. 2019. Pathogenicity and a TaqMan real-time PCR for specific detection of *Pantoea allii*, a bacterial pathogen of onions. Plant Disease (in press).

**Peer-reviewed technical reports**:

Dutta, B., Riner, C., Edenfield, J., Tyson, C., Tanner, S., Williams, Z., Shirley, A. and Earls, C. 2019. Evaluation of onion growth stage directed chemical applications on center rot incidence in onion bulbs in Georgia, 2018. PDMR13:V020.

Dutta, B., Edenfield, J., Tanner, S., Williams, Z. and Riner, C. 2019. Evaluation of fungicides to manage Downy mildew in Toombs County, Georgia, 2018. PDMR 13:V019.

Dutta, B., Foster, M.J., Donahoo, W.M., Coolong, T. and Riner, C. 2018. Evaluation of a pre-plant fumigant and a post-plant fungicide on the control of Fusarium wilt of watermelon in Toombs County, Georgia 2017. PDMR 12:V141.

du Toit, L.J., Derie, M.L., Holmes, B.J., Miller, C.E., Brouwer, L.R., Waters, T.D. and Darner, J. 2019. Effects of the arbuscular mycorrhizal fungi inoculant Mykos Gold Granular on pink root and yield in commercial onion bulb crops near Irrigon, OR, 2017. Plant Disease Management Reports 13:V008.

du Toit, L.J., Derie, M.L., Holmes, B.J., Morgan, P., Brouwer, L.R. and Waters, T.D. 2019. The influence of soil phosphorus levels on onion root colonization by mycorrhizal fungi from commercial inoculants, 2017. Plant Disease Management Reports 13:V009.

du Toit, L.J., Derie, M.L., Holmes, B.J., Henrichs, B.A., Winkler, L.R., Waters, T.D. and Darner, J. 2018. The effects of arbuscular mycorrhizal fungal inoculants on pink root and yield in an onion crop near Paterson, WA, 2016. Plant Disease Management Reports 12:V102.

**Extension publications**:

Dutta, B., Schmidt, J., and Johnson, W.C. 2019. Challenges faced by the organic and the organic-transition Vidalia onion growers in Georgia. In: VSC News Magazine. April 2019.

Hayden, Z.D., Leach, A. and Nault, B. 2019. Nitrogen: Is less more? Studies in Michigan and New York highlight potential for reducing nitrogen rates on muck soils. Onion World 35 (5):14-16.

Hoepting, C. 2019. Control of onion downy mildew when disease pressure is high. Cornell Cooperative Extension, Cornell Vegetable Program Veg Edge. 15(15):3-5.

Hoepting, C. 2019. Onion diseases of August. Cornell Cooperative Extension, Cornell Vegetable Program Veg Edge. 16(17):6.

Hoepting, C. 2019. Stretching onion fungicide spray programs to preserve useful longevity of FRAC 3/7. Cornell Cooperative Extension, Cornell Vegetable Program Veg Edge. 15(17):3-4.

Hoepting, C. 2019. News on fungicide resistance in New York and consequent changes to 2019 fungicide recommendations for Stemphylium and Botrytis leaf blight in onion. Cornell Cooperative Extension, Cornell Vegetable Program Veg Edge. 15(12):6-8.

Hoepting, C. 2019. Control of onion downy mildew with fungicides. Cornell Cooperative Extension, Cornell Vegetable Program Veg Edge. 15(10): 9.

Hoepting, C. 2019. Scouting tips for identifying downy mildew in onion. Cornell Cooperative Extension, Cornell Vegetable Program Veg Edge. 15(10):8.

Hoepting, C. 2019. My big fat onion variety nitrogen rot project. In: Proceedings of the 2019 Empire State Producers Expo, Syracuse, NY: 14-17 January, 2019. Online: [http://www.hort.cornell.edu/expo /pdf/20190116-1-hoepting.pdf](http://www.hort.cornell.edu/expo%20/pdf/20190116-1-hoepting.pdf).

Hoepting, C. and Nault, B. 2019. 2019 Cornell guidelines for onion thrips management in onion. Cornell Cooperative Extension, Cornell Vegetable Program Veg Edge. 15(14): 8-9.

du Toit, L. and Yorgey, G. 2018. Onion stunting after cereal cover crops. Page 6. Timing of glyphosate applications to wheat cover crops to reduce onion stunting caused by *Rhizoctonia solani*. Page 7. Efficacy of fungicide applications to manage onion stunting caused by Rhizoctonia spp. Pages 7-8. In: Strip-tillage for onions and sweet corn, Lorin Grigg. Farmer to Farmer Case Study Series on Increasing Resilience among Farmers in the Pacific Northwest. Washington State University Extension PNW702.

**Popular periodicals**:

Iglesias, L. and Nault, B. 2019. Tackling thrips in organic onions. Onion World 35(5): 7-9.

Winkler, L., du Toit, L., and Waters, T. 2019. Mycorrhizal inoculants: Yea or nay? The effects of mycorrhizal inoculants on onion crops in the Columbia Basin. Onion World Feb. 2019:10-14. https://issuu.com/columbiamediagroup/docs/feb\_2019\_onion\_world\_web?e=34405975/67413329

**Other Activities**

**1. Abstracts and Papers at International Professional Meetings**

du Toit, L.J., Waters, T.W., Derie, M.L. and Brouwer, L. 2019. Can onion growers benefit from mycorrhizal inoculants? 2019 combined meeting of the National Onion Association, National Allium Research Conference and International Allium Research Symposium, 24-27 July, 2019, Madison, WI. (Abstract)

Singh, N. and Cramer, C.S. 2019. Improved tolerance for onion thrips and Iris yellow spot in onion plant introductions after two selection cycles. Horticulturae 5:18. doi 10.3390/horticulturae5010018.

Mandal, S. and Cramer, C.S. 2019. Progress made for Fusarium basal rot resistance, p. 17. In: Proc. 2019 International Allium Research Symposium. M. Havey (Ed.) Madison, WI. (Abstract)

Mandal, S. and Cramer, C.S. 2019. Selection for Fusarium basal rot resistance using an artificial inoculation mature bulb method, p. 29. In: Proc. 2019 International Allium Research Symposium. M. Havey (Ed.) Madison, WI. (Abstract)

Kvitko, B., Stice, S. and Dutta, B. 2019. The best offense is a good defense: plasmid-borne allicin tolerance genes make major contributions to Pantoea spp. virulence on onion. International Allium Research Conference, Madion WI, 24 July, 2019.

**2. Abstracts and Papers at National Professional Meetings**

Agarwal, G., Kvitko, B., Stice, S. and Dutta, B. 2019. Whole genome sequencing of *Pantoea ananatis* strains to identify variants linked to onion virulence. International Allium Research Conference, 24 July, 2019, Madion WI.

Ilyas, U., Raizada, M., du Toit, L.J. and McDonald, M.R. 2019. Mycorrhizal fungi in the roots of onion and carrot in relation to mycorrhizal fungal inoculant and soil phosphorus. Plant Canada 2019, 7-10 July, 2019, University of Guelph, Ontario, Canada. (Abstract 192)

Kvitko, B., Stice, S. and Dutta, B. 2019. A chemical arms race in onions: plasmid-borne allicin tolerance genes make major contributions to Pantoea spp. virulence on onion. American Phytopathological Society-Plant Health 2019. Cleveland, OH, 6 August, 2019.

Mandal, S. and Cramer, C.S. 2019. Identification of steroidal saponins in onion basal plate tissue involved in plant defense against *Fusarium oxysporum* f. sp. cepae, In: Proc. 2019 National Allium Research Conference. M. Havey (Ed.) Madison, WI. (Abstract)

Mandal, S. and Cramer, C.S. 2019. Progress made for Fusarium basal rot resistance. In: Proc. 2019 National Allium Research Conference. M. Havey (Ed.) Madison, WI. (Abstract)

Mandal, S. and Cramer, C.S. 2019. Selection for Fusarium basal rot resistance using an artificial inoculation mature bulb method. In: Proc. 2019 National Allium Research Conference. M. Havey (Ed.) Madison, WI. (Abstract)

Scott, J.C., Jeliazkova, E., Cheng, Q., Qian, Y., Qian, M. and Dung, J.K.S. 2019. Evaluation of alternatives to soil fumigants and diallyl disulfide for the management of white rot. National Allium Research Conference, Madison, WI.

Stice, S., Dutta, B. and Kvitko, B.H. 2019. Gene cluster in onion bulb rotting bacteria contributes to virulence by conferring tolerance to reactive sulfur species. Annual Meeting of Southern Division American Phytopathological Society in Gainesville, FL (7-9 February, 2019)

**3. Reports at Grower Meetings and Field Days**

Cramer, C.S. 2019. Evaluation of onion germplasm to mitigate the effects of Iris yellow spot virus. Multistate Research Project W3008: Integrated Onion Pest and Disease Management, Annual Meeting, Madison, WI, 24 July, 2019.

Cramer, C.S. 2018. Progress for breeding for Fusarium basal rot resistance in onions. Multistate Research Project W3008: Integrated Onion Pest and Disease Management, Annual Meeting, and 2018 Pacific Northwest Vegetable Growers Association Annual Meeting, Kennewick, WA, 13 November, 2018.

Dung, J. 2019. White Rot Research: USDA-NIFA Grant Update. Invited speaker. California Garlic and Onion Research Advisory Board Allium Research Symposium. 11 February, 2019. Tulare, CA (~60 attendees)

du Toit, L.J. 2019. Specialty vegetable seed production. Invited presentation, Western Region IR-4 SLR/CLC Meeting, 9-10 April, 2019, Mount Vernon, WA. (25 people)

du Toit, L.J. 2019. Regionally appropriate fungicide programs. Invited presentation, Wilbur Ellis Grower Meeting, 21 Febuary, 2019, La Conner, WA. (50 people)

du Toit, L.J. 2019. Onion disease management. Invited presentation and discussion with Agri Northwest growers, 7 February 2019, Pasco, WA. (50 people)

du Toit, L.J. 2019. Late-season disease management in onion production. Invited presentation at Clearwater Supply Winter Growers’ Meeting, 6 February, 2019, Ontario, OR. (75 people)

du Toit, L.J. 2019. Regionally appropriate fungicide programs. Invited presentation, Columbia Basin Crop Consultants Association Short Course, 4-5 February, 2019, Moses Lake, WA. (150 people)

du Toit, L.J. 2019. Management of Rhizoctonia in onion seedbeds and direct-drilled crops, and postharvest management of black mold in onion crops. Invited presentation, KORKOM onion growers, 23 January, 2019, Ceres, South Africa. (15 people)

du Toit, L.J. 2019. Appropriate use of fungicides. Invited presentation, Columbia Basin Vegetable Seed Association Annual Meeting, 15 February, 2019, Moses Lake, WA. (75 people)

du Toit, L.J. 2019. Appropriate use of fungicides. Invited presentation, Annual Basin Producers’ 2019 Pesticide Recertification Day, 14 February, 2019, Moses Lake, WA. (275 people)

du Toit, L.J. 2018. Management of Fusarium basal rot of onion. Invited presentation, Onion Session of the Pacific Northwest Vegetable Association Annual Convention & Trade Show, 14-15 November, 2018, Kennewick, WA. https://pnva.org/2018-pnva-conference-presentations/ (200 people)

du Toit, L.J. Regionally appropriate fungicide programs for common onion pathogens in the Columbia Basin. Invited presentation, Onion Session of the Pacific Northwest Vegetable Association Annual Convention and Trade Show, 14-15 November, 2018, Kennewick, WA. https://pnva.org/2018-pnva-conference-presentations/ (200 people)

Ingham, R. and Waters, T.D. 2018. Nematode management in onions. Pacific Northwest Vegetable Association Annual Convention and Trade Show, Kennewick, WA. (200 people).

Malla, S. 2019. Vegetable & Wheat Spring Field Day. Texas A&M AgriLife Research & Extension Center, Uvalde, TX. May, 2019.

Mandal, S. and Cramer, C.S. 2019. Progress made for Fusarium basal rot resistance. 2019 National Onion Association Summer Convention, Madison, WI. July 24-27, 2019.

Mandal, S. and Cramer, C.S. 2019. Selection for Fusarium basal rot resistance using an artificial inoculation mature bulb method. 2019 National Onion Association Summer Convention, Madison, WI. July 24-27, 2019.

Mandal, S. and Cramer, C.S. 2019. Identification of steroidal saponins in onion basal plate tissue involved in plant defense against *Fusarium oxysporum* f. sp. cepae. 2019 National Onion Association Summer Convention, Madison, WI. July 24-27, 2019.

Reitz, S. 2018. Thrips and IYSV Management in the Treasure Valley. Pacific Northwest Vegetable Association Annual Meeting.

Reitz, S. 2019. Thrips/IYSV Management. Idaho-Malheur County Onion Growers Associations Annual Meeting Soilborne disease management in carrot, onion, brassica, and beetroot production in sandy soils of the Sandveld region of South Africa. Invited discussion/workshop with agronomists and production managers for Laastedrif Farm, 23 January, 2019, Ceres, South Africa. (12 people)

Waters, T.D. 2018. Thrips Management in Dry Bulb Onions. SW Ag Summit, Yuma, AZ. (100 people).

Waters, T.D. 2018. Thrips control in dry bulb onions. Pacific Northwest Insect Management Conference, Portland, OR. (60 people).

Waters, T.D. 2018. Insect control in potato and onion. Corteva Regional Customer Meeting, Las Vegas, NV. (60 people).

Waters, T.D. 2018. Thrips and seedcorn maggot control in onions. 2018 Walla Walla Onion Growers’ Meeting organized by CHS Primeland. Walla Walla, WA. (20 people).

Waters, T.D. 2018. Potato and onion insect IPM update. Agri Northwest Agronomy Meeting. Kennewick WA. (50 people).

**4. Newsletter Articles**

WSU Onion Alerts (https://mailchi.mp/wsu/wsu-onion-alert-aug-14-1303793?e=72ba613792): Time-sensitive topics covered in seven articles between 30 May and 21 August of 2019 included downy mildew, fungicides, thrips, nematodes, iris yellow spot, irrigation, and powdery mildew.

Gugino, B.K. 2019. Black mold on onion and other common diseases on onion. Pennsylvania Vegetable Disease Update. 3 July, 2019. <https://extension.psu.edu/vegetable-disease-updates-for-july-3-2019>.

Putman, A.I. 2019. Downy mildew of vegetables in Imperial County. Imperial County Agricultural Briefs 22(3): 39-42.

Putman, A.I. 2019. Transition period from downy mildew to powdery mildew. Imperial County Agricultural Briefs 22(4): 76-78.

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**5. Annual Reports**

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**6. Internet Resources**

Pacific Northwest Vegetable Extension Group (PNW VEG) website (<http://mtvernon.wsu.edu/path_team/vegpath_team.htm>), a tri-state Extension team with resources on diverse vegetables grown in the PNW USA. Sections on onions include the Photo Gallery (<http://mtvernon.wsu.edu/path_team/onion.htm>) and IPM Resources (<http://mtvernon.wsu.edu/path_team/ipmResources.htm#onion>).

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